Electrochemical and Metallurgical Industry

NEW YORK, JULY, 1909.

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Chemical and Metallurgical Geography.

Mr. Harriman has been accused of many things by the newspapers. So it was nothing extraordinary to hear a speaker at a recent American Electrochemical Society meeting remark that, after all, it is Mr. Harriman who decides whether a chemical reaction or a metallurgical process shall work and be a commercial success. Commercial success depends on two elements—cheap production and cheap distribution or an easy market. The question where to locate a plant so as to eliminate as far as possible Mr. Harriman and reduce transportation expenses, must be decided in each case on its own merits. It is often advisable to divide the whole metallurgical process into several steps and erect two plants. Thus in zinc metallurgy, because two or four tons of coal are needed to treat one ton of ore, it is cheaper to ship the ore than the coal. Hence, the zinc smelter will be placed near a coal field, but to reduce the tons of zinc ore to be shipped, a mechanical or magnetic concentrating plant is placed at the zinc mine. Or in copper metallurgy, we have the smelters in the West, but the refineries near the market at New York Harbor.

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The problem of finding the best location of a plant is always exceedingly complicated. Of the transportation expenses—which are often a very big item, not only in distribution, but also in production—we have spoken. Then comes the power cost, the labor problem, and all the other items which enter naturally into production and distribution. Then there may be considerations in connection with protective duties. As a monumental example of the lack of foresight in this respect there stands, idle for years, in Bayonne, N. J., a large tin smelter, which never started operation because the expected ore supply from the Straits Settlements was cut off by legal provisions keeping the ore in the Settlements. But this is an exceptional case. In electrochemical industries the cost of power is often of very decisive importance. Hence we have the large centers of electrochemical industries at Niagara Falls, in Savoy, France, and now at the Norwegian coast, where immense water-powers are available and shipping facilities by ocean steamers are excellent. It is quite natural that the new electric furnace industry of making nitrates and nitric acid from air is settling down in Norway. With respect to raw materials this industry is not bound to any locality, since air is everywhere available. But this industry needs, above everything else, very cheap power. This is available in Norway. Then the industry needs a market for the products; this is supplied chiefly by other countries, the transport by ocean steamers being cheap. If this industry shall settle down in this country, the transport facilities will have to be taken into account as the decisive factor. With respect to cheap power we can hardly expect to compete successfully with Norway.

Atomic Weights.

The article by Dr. Hinrichs, published in this issue, appears to call for a word of introduction. We believe that everybody who earnestly and honestly searches after truth should have his say, and since Dr. Hinrichs has not had an opportunity to present his views in American chemical journals for many years past we have been very glad to place our columns at his disposal. The importance of the subject is beyond question, even for applied chemistry. Dr. Hinrichs' theory is an exceedingly clever and interesting elaboration, with many important modifications, of the old hypothesis of Trout. But Dr. Hinrichs has so far been very decidedly in the minority. To sketch impartially the situation, we cannot do better than quote the concluding words of a review of a former book of Hinrichs, written by Dr. Wilder D. Bancroft in his *Journal of Physical Chemistry*, Vol. VI, page 59: "The reviewer is not as yet prepared to say that Mr. Hinrichs is right in his conclusions, but it does seem as though the question of the atomic ratios was distinctly an open one. It seems also as though it would be profitable to science if some of the data accepted by Mr. Hinrichs should be verified and that work of this sort is of far more immediate importance than to determine the atomic weights of a large number of elements. There is another way of looking at this matter which may be profitable. What does the fact that the views of Mr. Hinrichs have not been accepted prove in regard to their accuracy or inaccuracy? Absolutely nothing at all. The natural conservatism of scientific men is so great that a revolutionary truth has to fight its way and to fight hard. Mr. Hinrichs has never made any atomic weight determinations himself, nor has he ever had students who have done so. This has been fatal to the acceptance of his views, but it has proved nothing in regard to their merit. The question at issue is not one of manipulation, but of the critical interpretation of results. The man with great manipulative skill may also have a highly developed critical sense, but it is not necessarily the case and the two faculties are quite as likely to be found separately as together. Consequently, two of the arguments against Mr. Hinrichs fall to the ground, namely, that his views must be wrong because they have not met with favor and that he is not qualified to judge because he has never shown his ability to make atomic weight determinations. The whole question is, therefore, open and can be broadly stated as follows: Do the methods approved by Hinrichs give the results he thinks they do?"

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Since these words were written by Professor Bancroft five years ago, much important work has been done by skillful, conscientious and enthusiastic experimenters. On the other side, Dr. Hinrichs has continued his analysis and interpretation of the experimental results of others. His article in this issue, and especially the table summing up on a single page the results of many years of experimental work, will prove exceedingly interesting reading, even if one disagrees with the polemical portions of the paper. This journal is no party in this controversy. No man, nor method, has a monopoly of searching after truth. The finding of truth is always the result of a clashing of ideas. It is unnecessary to add that after we have gladly placed our columns at the disposal of Dr. Hinrichs, they will be open to the other side for a reply. And we sincerely hope that a general clearing of opinions will be the ultimate result.

Liquid Chlorine.

For many years the great Badische Anilin und Soda Fabrik, in Germany, has liquified electrolytic chlorine for its own use as an oxidizing agent in the manufacture of coal-tar dyes, and has also sold its surplus product. Other large German chemical concerns have likewise produced liquid chlorine. But heretofore the stamp on the cylinders of liquid chlorine used in this country has always been "Made in Germany." At the present time, however, at least three of the concerns in this country which decompose brine in the electrolytic cell are preparing to dispose of this product as liquid chlorine. The manufacture of liquid chlorine out of the gas presented at first several serious difficulties. But by employing several stages of cooling and compression, by drying the gas so absolutely that its corrosive properties are nullified, the process lost its serious troubles and has been reduced to a practical basis.

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There is no danger in the use of liquid chlorine. In fact, the flow of gas can be controlled by the outlet valve with perfect and surprising ease. In Germany the liquid chlorine has been transported in tank cars without any accidents of a serious nature. The uses of liquid chlorine are many, for it can replace bleaching powder almost in every instance. For bleaching in textile mills, for making stannous chloride out of tin scrap, in the artificial dye industry, in the chemical works as a perfect oxidizing agent, and in chlorinating gold ores, in all these cases liquid chlorine can be adopted as a substitute for bleaching powder. In addition, in every analytical laboratory liquid chlorine when once used will be found to be indispensable. There are a great many practical difficulties inherent in the absorption of chlorine by quicklime in chambers especially in weather like that prevalent recently. In addition, over 10 per cent of the chlorine is often reduced to calcium chloride, and is thus rendered unavailable. The cost of lime is high and the cost of the package for the bleaching powder increases the cost to the consumer of the "great oxidizer."

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With cheap power, the cost of compression of chlorine is not large. And every electrolytic caustic-chlorine plant has cheap power. The cylinders for the liquid chlorine should be made seamless and hence the first cost for them, as well as for compression plant, is somewhat high. But when these are once amortized, the charge is, of course, small. Ultimately there will be a great national gain when liquid chlorine replaces bleaching powder in this country's great industries. And this result will be reached slowly, but surely, for economic pressure overcomes "commercial inertia."

Keeping Watch in Concentrating Plants.

It is with particular pleasure that we call attention to Dr. Rudolf Gahl's paper in this issue on calculations in ore concentration. With the rapid growth in the size of modern industrial and manufacturing plants, it has become of utmost importance to exert one's self to keep close watch of the whole operation and all its details. Elaborate book-keeping methods, indicating and recording instruments have become of widest

use. The simplest case is probably found in an electric generating plant, if we consider the electrical part alone, where the use of indicating or recording voltmeters, ammeters, wattmeters, etc., gives directly and easily all the information desired. It is much more difficult in boiler plants and metallurgical furnace plants; but the rapidly growing use of carbon-dioxide recorders and of pyrometers means a great simplification of the operation and a much more rigid control than was formerly possible. In ore concentrating plants, where very large values are at stake, no such simple recording instruments are available. We have to rely chiefly on screen tests and assays.

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Screen tests and assays need interpretation. Thus the personal equation comes in. This is a disadvantage and an advantage. We like recording instruments, for instance, chiefly because they are impersonal, because they give us a permanent impartial record. This is a very great advantage, but we should not overlook the possibility of an instrument reading wrong; and if such a case occurs, it will read wrong always in the same direction; this is part of its impartiality. With human beings it is different. We can assume with a certain degree of probability that the mean of a number of assays is about right. But assays and screen tests need interpretation; that means work, conscientious and careful thinking. An ordinary workman can read an instrument. The interpretation of assays and screen tests—if carried out to its limits, as shown in Dr. Gahl's paper—requires a good engineer. Although the error in screening expressed in percentages may be greater than the error in assaying, there are cases in which the results based on screen tests are much more reliable. It is for the chemical engineer to decide that in each case.

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As Dr. Gahl shows in his paper, we can check the results of assays against the results of screen tests. Or we may figure the "saving" of a concentrating mill (the ratio of valuable metal in the concentrates to the valuable metal in the ore) from assays of heads, concentrates, and tailings alone, or we can find the same figure from the assays in combination with the weights. We have, in all, four ways of calculating the saving and checking the result. And thus we eliminate the personal equation. All these calculations, as Dr. Gahl shows, require very simple mathematics only. But they require some engineering judgment. The moral of Dr. Gahl's paper is that if assays and screen tests are made in a concentration mill, it is the clear duty of the engineers in charge to make the utmost of these assays and tests, by extracting, with the aid of simple calculations, all the technical information that is hidden therein —concerning the saving, the rate of concentration, the distribution of pulp in the mill, etc.

A Bit of Friendly Criticism.

Robert Burns, Scotland's national poet, made in his quaint old dialect the very pointed query, "Oh, wad some power the giftie gie us to see ourselves as others see us." This is applicable to each and every one of us. It is likewise apropos of nations and it is interesting to see what other nations think of us. Nations, just like individuals, rarely have the "giftie" so requisite for correct self-judg-

ment. For a nation, philosophically considered, is an individual, it has a physical body and an inspiring soul. Probably the general reading public in America know about as little about finance and political economy as about anything else. Hence the comments of the European financial journals about American industry are interesting, for they are sane and fair, even though they are imbued with old-time conservatism and do not fully appreciate the marvelous recuperative powers of this youthful nation.

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One of the most impartial of these periodicals—the "Economiste Français"—is now looking upon our immediate industrial future with smiling eyes and a beaming countenance. But at the same time it utters a note of warning and caution. Our increasing railroad earnings with net increasing faster than gross, the revival in the building trades especially in the West, the "telling of the tape" in Wall Street, where the discounting of the future is made a business, all these our Gallic contemporary believes to be the "signs of the dawn." It also points out, quite pertinently, we should say, that "if all the panic's consequences are not yet effaced, if the patient still needs a moderate diet, and if his best wishers still hope that he will not indulge too quickly in the violent agitation of a boom, nevertheless health is returning to his organism." This expresses almost precisely the views of this journal so often given in these columns. Thus modesty forbids us doing more than commending the good common-sense of the "Economiste Français" in looking at our country with the idea of proportion, with a sense of our underlying strength rather than, as so many foreigners do, mere scrutinizing in the hope of finding minor superficial defects.

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In conclusion, the French journal points out the importance of our having good crops this year to finish the sinews of war for "the prodigious industrial impulse recently developed," though it admits that we are each year less and less of an agricultural community, and hence not so dependent as formerly on good crops. "Such an accident as poor crops," it continues, "will not stop recovery, that is dependent on the wisdom and good sense of the Americans. They must not yield to the tendency to go too fast. If they are willing to move ahead at a prudent pace, they have a growing prosperity ahead." This is all admirably to the point. It is good advice and friendly counsel. For our own part, let us say that the United States as a nation is endowed with remarkable originality, with great energy, and with what the Germans call so expressively, "Geist." It has rich broad acres and enormous mineral wealth. The combination of great national resources and national physical vigor and mental energy makes for immense and rapid national growth. The reaction from the periods of growth is naturally more marked in this country, which grows so fast, than in a country like France, that is more or less stationary. But we as a nation are passing out of the period of adolescence, and it behooves us to conserve our powers and expand at a more uniform rate. Friendly criticism like this of the "Economiste Français" will help us to attain this end, for friendly criticism is the only kind to which most of us will listen.

International Congress for Mining and Metallurgy, Düsseldorf, 1910.

The last International Congress for Mining, Metallurgy, Applied Mechanics and Practical Geology was held in Liege, Belgium, in connection with the 1905 exhibition. In its last session the congress decided to accept the invitation of the manufacturers of Rhineland and Westphalia to hold the next congress there.

In accordance with this decision the congress will be called for the end of June, 1910, to Düsseldorf, Germany. Much is already being done in the way of preparations for this congress. It will last about a week. Besides sessions for the reading and discussion of papers, visits will be paid to scientific institutions and industrial plants, and excursions will be made to districts of geological interest.

Further details of the program of the congress and the exact date will be given later. Inquiries should be addressed, and titles of papers to be presented should be sent to the Arbeitsausschuss des Internationalen Kongresses Düsseldorf 1910, Jacobisstrasse 3/5, Düsseldorf 15, Germany.

National Irrigation Congress.

The Seventeenth National Irrigation Congress meets in Spokane, from August 9 to 14 next, for the consideration of and action on irrigation, drainage, forestry, deep waterways, good roads and home building—all these subjects being of such importance for the solution of the problem of the conservation of our natural resources.

Mr. George E. Barstow, of Barstow, Tex., is president of the congress; Mr. B. A. Fowler, Phoenix, Ariz., secretary; Mr. R. Insinger, of Spokane, chairman of the board of control; and Mr. Arthur Hooker, Spokane, secretary of the board of control.

Association of Iron and Steel Electrical Engineers.

The second annual convention is to be held at Buffalo, N. Y., from June 23 to 26.

June 23 is designated as "Members Day." The president, Mr. John C. Reed, will present his address. The treasurer, Mr. E. W. Yearsley, and the secretary, Mr. G. H. Winslow, will present their reports. The reports of the Standardizing Committee and the Safety Committee will be read and discussed. Two lectures on the electric furnace are to be delivered on this day, one by Mr. E. W. Yearsley and the other by Mr. P. McN. Bennie.

June 24 is "Visitors' Day." The program for this day is as follows:

Westinghouse Electric & Manufacturing Company: Some Important Phases of Electrical Power for Steel Mills, by Mr. C. F. Scott; Motor and Control Apparatus for Steel Mills, by Mr. B. Wiley.

The Electric Controller and Manufacturing Company: A Steel Mill Starter for Direct-Current Motors, by Mr. C. Pirtle.

The C. J. Toerring Company: Flaming-Arc Lamps, Operation and Demonstration, by Mr. C. J. Toerring.

American Fuse Company: Allen-Bradley Controllers and Starters, by Mr. Lynde Bradley.

General Electric Company: New Developments in Electric Apparatus, by Messrs D. B. Rushmore, Pauly and Whiting.

Crocker-Wheeler Company:

Westinghouse Machine Company: Leblanc Condenser, by Mr. Edwin Yawger.

For June 25 visits are planned to various steel works, like the Lackawanna Steel Company, the Seneca Iron & Steel Company, also to other plants at Buffalo and vicinity.

On June 26 excusions will be made to Niagara Falls and its electric-power plants.

Brooklyn Meeting of the American Institute of Chemical Engineers.

While this number is going to press the Brooklyn meeting of the American Institute of Chemical Engineers has begun on June 24 under very favorable auspices.

The meeting, which is being held at the Polytechnic Institute in Brooklyn, was opened on June 24 by an address of welcome by Mr. Herman A. Metz, the Comptroller of New York City, and himself a manufacturing chemist, and by Prof. Irving W. Fay, of the Polytechnic Institute.

During the morning session two papers were read. Prof. W. D. Ellis discussed the limits of efficiency of the power gas producer, calculating theoretically the possible efficiencies with air alone, or with steam or waste gas added. The paper was discussed at some length.

Dr. O. K. Zwingenberger dealt in his paper with the utilization of low-grade fuels in the United States, discussing especially peat gas producers.

There was a short business session at noon while Mr. Jerome Alexander made an interesting demonstration of the ultramicroscope in an adjoining room.

The papers on the program for the afternoon dealt with creosote oil from water gas tar, by Dr. S. P. Sadler; case hardening of steel with gas, by Dr. J. C. Olsen; automatic acid egg, by Mr. Richard K. Meade; the centering of great industries in the New York Metropolitan District, by Dr. C. F. McKenna; methods of clay control, by Mr. J. G. Dean. After the exceedingly hot day a subscription dinner was greatly enjoyed in the evening at the Brighton Beach Hotel.

The program for Friday, June 25, and for Saturday, June 26, contains various interesting excursions. Friday a visit is first paid to the Atlantic White Lead and Linseed Oil Works in Brooklyn, from there the party is taken by steamer up the Hudson River, with visits to the Edgewater plant of the Corn Products Refining Company and the Edgewater plant of the Warner Sugar Refining Company.

Among the excursions scheduled for Saturday, June 26, is one to the Standard Oil Company's plant at Bay Way, N. J., and to the plant of the Consolidated Gas Company at Astoria, L. I. We reserve for our next issue a full report of the meeting with abstracts of all the papers presented.

National Electroplaters' Association.

At the second meeting of the National Electroplaters' Association of the United States and Canada, held in New York City on May 7, the were 28 members present. The president is Mr. Charles H. Proctor, supervisor, F. H. Lovell Company, Arlington, N. J.; the secretary is Mr. Benjamin Gilchrist, foreman plater, Lalance & Grosjean Manufacturing Company, Woodhaven, N. Y.; the treasurer is Mr. Nathan S. Emery, foreman plater, Victor Typewriter Company, New York.

The Iron and Steel Market.

The finished steel trade has reached a rather quiescent stage as to new buying after a period of great activity. When the general drop in prices occurred immediately upon the announcement of an "open market" February 18, there was very litttle buying. In the course of two or three weeks, shading began to appear from the prices as originally reduced, and gradually a general buying movement was inaugurated which rapidly gained in intensity. The total transactions in March probably did not exceed the average of last year, while April business greatly exceeded that of March, and May again showed a great gain over April. The total tonnage booked in March, April and May, partly in contracts and partly in definite orders, was equal to considerably more than three months' full production. In June this new buying was reduced to very moderate propor-

tions as regards jobbers and general consumers, but a new interest—the railroads—bought more heavily in June than they had in any of the immediately preceding months. In the closing days of April and during May there were a number of price advances, covering bars, plates, shapes, wire products and light rails.

In the heavy buying movement, the object of jobbers and consumers was to take advantage of the specially low prices available and to cover for some distance ahead. The mills, in making specially low prices, desired to obtain specifications for immediate rolling. At the outset the general tendency was to limit the low prices to material which would be taken out before July 1. Later the lines were less closely drawn, and contracts were entered with the proviso that a certain tonnage should be specified prior to July 1. It is generally admitted that in this movement buyers obligated themselves to specify a greater tonnage of material before July 1 than they would actually need. In a sense, this excess was speculative, while to an extent it merely involved an increase in current stocks in the hands of jobbers and consumers from an extremely low level to a level more in keeping with the amount of material being moved.

The production of steel has been steadily increasing to meet the specifications received, until at the close of June the steel industry proper is producing a tonnage within about 90 per cent of the greatest ever attained. The production of pig iron has reached a rate between 80 and 85 per cent of the maximum, the difference between pig iron and steel production being due to the fact that the foundry industry, which in 1907 consumed about 30 per cent of the pig iron made, has not reached the same degree of activity as the steel industry proper.

The beginning of July is evidently a crucial time in the steel industry. By reason of the terms of many of the contracts entered, buyers have been specifying, and mills have been running at a greater rate than the actual rate of consumption, but how great the excess is cannot be determined. After July 1, the requirements that buyers shall specify will partly disappear; but should the rate of specifying immediately decline, the result would not be felt immediately in production, because July 1 finds an accumulation of specifications. As a general average, it is probable that mills have actual specifications for from three to five weeks' solid work.

With no change in the rate of actual consumption, it might easily occur that specifications entered during the third quarter would show a material reduction, and production of steel would have to decrease. This possibility is recognized, but an optimistic feeling is professed in the steel trade, based chiefly on the expressed expectation that the actual rate of consumption will steadily increase.

As to the reasonableness of this expectation there may be some question. With steel products being made at a rate about 90 per cent of the highest ever reached, it remains the fact that the production of railroad material is far below the maximum, and without any close analysis of percentages it must be admitted that the rate of producing materials outside of those used by railroads actually exceeds the maximum ever attained. It might be regarded as difficult to break the previous record, with general business in a more or less depressed condition, but on the other hand, the iron and steel trade has repeatedly found, on emerging from a period of depression, that consumptive requirements have grown meanwhile, so that when normal conditions are restored they involve a larger tonnage than formerly.

Railroad Buying.

There was a concentration of railroad buying during June, large orders being placed for rails, cars and locomotives. The aggregate has been large, for a single month, and the reports of individual transactions have made quite a formidable showing. Such transactions, during a limited period, afford little guidance as to prospective rate of production, because deliveries may be required slowly. They do show distinctly the tendency of buyers, but there is some question as to the fundamental cause of the tendency when shown. It would be idle to deny that the general business situation is a highly speculative one, as evidenced in particular by the manipulation of the stock market, and in this general situation it is far from unreasonable to suspect that the tendency on the part of certain railroad interests to buy may be based more upon a desire to create a favorable showing for business than upon a desire to receive and at once use the material bought. Thus it has been reported that while the Harriman lines contracted for about 150,000 tons of rails during June, deliveries are not to commence until the fourth quarter.

Summing up, then, it may be said that while prospects are that general business and the actual consumption of iron and steel will continue to improve, it does not follow that such improvement will require a greater rate of output of iron and steel than has been witnessed in June. The present situation is, in a measure, artificial, and by so much as this artificiality is not being recognized at this time, the iron and steel trade, with its present extreme optimism, may be laying the foundation for one of those reversals in temper in the next two months which it has so often experienced.

Pig Iron.

There has been a sharp advance in pig iron in all markets, but particularly in the Central West. During the month prices in the valley market (freight to Pittsburg 90 cents) have advanced as follows: Bessemer, from $15 to $15.50; basic, malleable and No. 2 foundry, from $14.50 to $15, and forge from $13.50 to $14.25. Sales of foundry iron have been fairly large in the Central West, the East and the South, but in the immediate Pittsburg district have been relatively light. In the East there was a heavy movement in basic, following the buying in May, the total movement in the two months to Eastern steel works exceeding 200,000 tons. In the Central West, sales of basic have been fairly large. Bessemer has been neglected, outside the purchases of the Republic Iron & Steel Company and some small buying by other interests. Both basic and Bessemer in the Central West have been moving much more freely on regular contracts, based upon month adjustment according to the average market price. The minimum of the valley market at the close of the month is $15 on basic, No. 2 foundry and malleable, it being difficult to do these prices even for early delivery, while for third quarter or second half $15.25 to $15.50 is asked. Bessemer is at a minimum of $15.50, valley, while sales for fourth quarter would not be made except at an advance. Prices delivered Pittsburg are 90 cents above the market at valley furnace. The Southern market became decidedly firmer during June. In the forepart of the month No. 2 foundry could be purchased for early delivery at $11, Birmingham, deliveries over the third quarter being nominally $11.50. Towards the close of the month, all iron below $11.50 disappeared, this price being still quoted by a few interests, several important producers advancing their asking price to $12. In some quarters it is held that the Southern position is not fundamentally as strong as appears on the surface; that while the furnaces are technically sold up for third quarter, there is a question about the iron being taken on time, and that the appearance of any weakness would precipitate a selling movement which would promptly break the market.

Billets and Sheet Bars.

Early in June there was a heavy movement in sheet bars at cut prices. While the nominal price has been $25.50 for sheet bars, delivered Pittsburg, Wheeling, Youngstown, etc., sales were made for forward delivery at $24 and even at $23.50. Toward the close of the month the market firmed to $25 for Bessemer and $25.50 to $26 for open-hearth, the latter material proving to be relatively scarce. In billets, also, there is a mild scarcity of open-hearth, and premiums have been obtained in some cases over the regular price of $23, Pittsburg.

In Philadelphia billets are held at $25, delivered, and in Chicago at $24 to $25 delivered, the market at each point not showing the full freight advance over the Pittsburg price.

Finished Material.

There have been no important price changes in the month. Some mills have advanced their asking prices on bars to $1.25, and on plates and shapes to $1.35, but there are still sellers of bars at $1.20 and of plates and shapes at $1.30. Indeed, in exceptional cases, plates are sold at $1.25. A nominal advance in iron bars at Pittsburg was made from $1.30 to $1.45, not in the expectation that sales could be made at the advanced price, but in the hope of inducing better specifying on old contracts. This expectation has been realized in a measure. The market is quotable as follows, f.o.b. Pittsburg:

Steel bars, $1.30, base.

Iron bars, $1.45, base.

Plates, $1.25 to $1.35.

Shapes, $1.30 to $1.35.

Standard rails, $28 for Bessemer and $30 for open-hearth, f.o.b. mill; light rails, 25 to 45-pound, $25.50 to $27.

Sheets, 28 gage, black, $2.20; galvanized, $3.20.

Tin plates, $3.40 for 100-lb. cokes.

Merchant steel pipe, ¾ to 6-inch, inclusive, nominally 80 off in "jobbers' carloads;" actual inside price, 81 and 5 off.

Plain wire, $1.50, base; wire nails, $1.70, base; painted barb wire, $1.70; galvanized barb wire $2.00.

CORRESPONDENCE

Electric Resistivity of Fused Steel.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—In his recent American Electrochemical Society paper on the calculation of the Gin induction furnace, Mr. Gin gives the resistivity of steel in electromagnetic units. Practicing engineers, however, generally prefer to use the more practical units, namely, the ohm, cb. cm. or cb. in. units of resistivity, and as the conversion of one to the other is troublesome, in so far that errors are likely to be made, I have reduced his figures to practical units, and have taken the opportunity to add others for the sake of comparison and for giving an idea of the numerical values of these constants:

	Material	Temp.C°	Restivity cm.	Restivity inch	Conductivity cm.	Conductivity inch
1	Fused steel...	not given	0.000,140	0.000,055	7,140.	18,100.
2	Fused steel...	not given	0.000,000	0.000,079	5,000.	12,700.
3	Fused cast iron	280–1340	0.000,16	0.000,063	6,502.	15,900.
4	Iron and cast steel	about 1300	6.000,114	0.000,045	8,750.	22,200.
5	Puddle steel....	15°	0.000,014,1	0.000,005,54	71,100.	181,000.
6	Bessemer steel..	15°	0.000,023,2	0.000,009,16	43,000.	109,000.
7	Pure copper...	15°	0.000,001,687	0.000,000,664	592,800.	1,505,000.

1. Gin. From present paper; lowest value 140,000 electromagnetic units.

2. Gin. From present paper; highest value 200,000 electromagnetic units.

3. Gin. From his paper on "Note on the Electrical Resistivity of Iron and Steel at High Temperature," Trans. Amer. Electrochem. Soc., Vol. VIII., 1905, p. 289. This, I pointed out in the discussion, was a million times too small; this correction has been made here.

4. W. Kohlrausch. Landolt & Boernstein, 2d Ed., p. 468. The conductivity of cast steel at nearly white heat is given as 0.826 in terms of mercury at 0°, and that of electrolytic iron at yellow heat as 0.8196. Hence approximately 0.823 for either is near enough for the present comparisons.

5 and 6. Kirchhoff & Hansemann. Both taken from the L. & B. tables, 3d Ed., p. 716, in the form of the conductivity in centimeter units.

7. The Matthiessen value according to Lindeck, given here merely as a standard of comparison.

In the table, the resistivity units are in terms of the ohm, cb. cm. or the ohm, cb. in. units, and the conductivities in the reciprocal ohm (or mho), cb. cm. or cb in. units. The reference numbers designate the origin of the data, which is given below the table. It will be noticed that the resistivities of molten iron and steel are, roughly, about ten times that of the solid metal at ordinary temperatures; also that molten iron appears to have a resistivity of the order of, and approximately equal to, that of mercury at ordinary temperatures. It will also be noticed that more reliable information concerning these constants is badly needed, as this data is of great importance in the proper calculation of electric furnaces for steel and iron.

Philadelphia, Pa.   Carl Hering.

Electric Pig-Iron Plant in Sweden.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—Believing that the starting of an electric pig-iron plant in Sweden is an interesting pioneer undertaking I send you a few data concerning this new undertaking. As your journal has already noted this new development, the following details will prove interesting:

A new company, "Trollhättans elektriska järnverk (The Electric Iron Company of Trollhättan), has recently been organized in Stockholm for electric smelting of iron ore for pig-iron production on a commercial scale. The methods to be employed are those worked out by Aktiebolaget Elektrometall in Ludvika, Sweden. The new plant is to be erected at Trollhättan, where the Swedish Government owns a large hydro-electric power station, from which electric energy is sold at cheap rates to surrounding cities and industrial consumers. The falls amount to about 75,000 hp, but will in future, after regulation of the Lake Venern, give 150,000 hp.

The first installation is to consist of three iron-ore reduction furnaces of 2500 hp each, of which one furnace is to be in reserve. The yearly production is calculated at 15,060 metric tons of pig iron, or 7500 tons for each furnace. Electric power will be bought from the Government at the rate of $7.46 per hp-year for the first 10 years and at $10 per hp-year for the following 10 years. A preliminary contract for renting up to 10,000 electrical hp has been drawn up.

The pig iron produced is intended to be used only for foundry purposes and to contain 0.4 — 1.0 per cent of phosphorus. Phosphorus-carrying ore from the Grängesberg mining district will be used. For the reduction of the ore German coke will be used from the Westphalia district, costing at Trollhätten $5.60, which is considerably cheaper than the Swedish charcoal ordinarily employed in Swedish blast furnaces.

The pig iron is calculated to be produced at $13.65 per ton.

The cost of the erection of the new plant is calculated as follows:

Three smelting furnaces, 2500 hp each	$40,000
Ladles, ladle-cars and various appliances	4,000
Crushing plant for crushing 35,000 tons of ore and 7000 tons of coke annually	2,400
Electric transformer and motors for crushing plant, transportation, lighting	1,600
Machinery for conveying ore and coke from harbor to crushing plant and from there to top of furnaces	4,000
Machinery for conveying pig iron and slag, and tracking	3,200
Buildings for furnaces and coke storage	16,000
Building for crushers	1,100
Excavation, grading, fencing and harbor	4,000
Office and laboratory	5,500
Superintendence and incidentals	9,100
Royalty	6,700
Total	$97,600

Ousby, Sweden.   H. Hullegård.

International Congress of Applied Chemistry in London.

(From Special Correspondents.)

The London congress has turned out a brilliant success. The next congress will be held in 1912, in the United States, with Dr. Nichols as president and Dr. Morley honorary president—certainly a good combination. The official United States delegates were elected a provisional organizing committee with power to add to their number. There is lots of work in store.

As I said, the London congress was a brilliant, a very brilliant success which I shall never forget. I would have liked to send you a description of the main features, but we have been so much engaged for a week in a maelstrom of festivities, functions, receptions and lectures that there is no time left to sleep nor to think. And there are many who think that in spite of the high value of many of the papers presented, the chief value and importance of the congress must be found in the personal intercourse between the members from different countries.

Yet the most enjoyable part of my trip has been and will

SIR WILLIAM RAMSAY.

remain our little party on the S.S. *Kroonland*. About 40 in all, chemists with their wives or daughters, or with their bachelorship. For once we poor chemists owned a ship—captain, steward, brass band and all—and never was there a heartier jollity, no horseplay, just boyish, cheerful wit. The most exuberant ones were the boys over 60, like Wiley, Clarke, and Elliot.

During the whole trip there was not the slightest trace of anything but happy, cheerful, kind feelings. Only once in a while saw we pass silently a shade—one of the six odd fellow passengers who were not chemists:

> "If you ain't a chemist,
> You needn't come 'round.
> The only men that I could see
> Were those who dealt in chemistree."

My only regret was that so many good fellows, dear friends, fellow chemists, were not among us and thus missed the never-to-be-forgotten floating chemical steamship.

In London social entertainments were provided by our English friends on a most lavish scale. It is impossible to state all functions that were noteworthy. I only mention the reception at the Foreign Office, the conversazione at the University of London and Imperial Institutes, and the visit to Windsor. . . .

And yet how great, how powerful, how healthy our own dear country is, becomes more apparent to anyone who will look on this mosaic from abroad, and is not further influenced by small irksome details which once in a while make us forget its magnificent ensemble. The finest canvas of a Van Dyck examined under the magnifying glass would only appear as a rather mixed-up, unesthetic agglomeration of paint strokes.

Every trip to Europe makes us love our own country still better, though we would be fools not to recognize what is really great and beautiful in the older culture of Europe. And in returning from Europe, we take with us the memory of innumerable little acts of gracious kindness shown us lavishly by our cousins beyond the sea. A very hard task will be before us in 1912 when we must endeavor to return Europe's hospitality with equal grace and success.　　X. Y. Z.

* * *

The seventh International Congress of Applied Chemistry was solemnly opened by the vice-patron, the Prince of Wales, on Thursday, May 27. The congress met under the patronage of the king; the Prince of Wales was vice-patron; Sir Henry Roscoe, honorary president; Sir William Ramsay, president, and Mr. William McNab, honorary general secretary.

In his opening address the Prince of Wales emphasized that the rule of thumb is dead and the rule of science has taken its place. Sir Henry Roscoe thanked the prince, and Sir William Ramsay welcomed the members of the congress in four different languages. Dr. Harvey W. Wiley, of Washington; Prof. Armand Gautier, of Paris; Prof. Otto N. Witt, of Berlin; Prof. Paterno, of Rome, and Prof. Svante Arrhenious, of Stockholm, replied for the different countries.

At the concluding session, Sir William Ramsay announced that over 3000 members and over 600 ladies had assembled.

There were almost 1000 papers presented before the 11 different sections. Section X (Electrochemistry) was the most crowded, and discussion was almost impossible on account of the large number of papers. This must be avoided in the future by subdividing this section.

It is clearly impossible to give even a brief summary of the whole program. We will dwell only briefly on some papers of general interest.

* * *

National and International Conservation of Water Power.

Mr. EDWARD R. TAYLOR, of Penn Yan, N. Y., one of the presidents of Section X, and chairman of the conservation committee of the American Electrochemical Society, presented a very interesting lecture on this subject.

Mr. Taylor quoted from a report of the recent joint conservation conference in Washington: "The annual stream flow —by which is meant the volume of water annually passing into the sea—is approximately 70,000,000,000,000 cu. ft. for continental United States. Of this less than 1 per cent is restrained and utilized for municipal and community supply and related purposes; less than 2 per cent (or about 10 per cent of that in the arid and semi-arid regions) is used for irrigation; about 5 per cent is currently used for navigation, and less than 5 per cent is utilized for the production of power. From 85 to 95 per cent of the total volume of water is wasted in floods." . . .

"The amount available at a cost comparable to that of steam installation is estimated at 37,000,000 hp; this 37,000,000 hp exceeds our entire mechanical power now in use, and would operate every mill, drive every spindle, propel every train and boat, and light every city, town and village in the country. The direct yearly damage by floods since 1900 has increased steadily from $45,000,000 to $238,000,000; the indirect loss through depreciation of property is still greater; while the largest loss is that arising from the impediment to navigation and terminal transfers.

"We should adopt at once a broad plan of waterways improvement to all the uses of the waters and the benefits to be derived from their control, including the clarification of the water and the abatement of the floods, for the benefit of navigation, the extension of irrigation, the development and application of power, the prevention of soil wash, the purification of streams for water supply, and the drainage and utilization

of the waters of swamp and overflow lands. Rough estimates of the cost of such practical improvement place the figure at $50,000,000 annually, the conclusion being reached that the work could be done in 10 years.

"If this work were to be done at the cost of the people the additional tax burden would be 62½ cents per year per capita, or $6.25 in all. Estimates of the total benefits resulting from such improvements place the figure at one billion dollars, or $12.50 per capita annually; that is, 20 times the cost."

As an illustration of what can be done, but as a typical illustration, Mr. Taylor referred to "a little brook that one can step across. With a dam made in a simple way by stones from the surrounding fields a canal leads the water to the little shop where 25 hp of water is developed.

"Once there were 89 sawmills on that stream. Now there is

EDWARD R. TAYLOR.

but that single water-power development. Suppose each one could develop this 25 hp, and all was fed into one system, that would mean 2225 hp from that single little brook, with the impounding and conservation of a large quantity of water, and the saving of the equivalent of 30,000 tons of coal per year, worth at $2.50 per ton, $75,000 per year. A nice showing for a little brook, isn't it? But it is wasted, and as an engineer, W. P. Lay, of Alabama, would say equal to 30,000 tons of coal per year falling to waste over a precipice. . . .

"When you come to the rivers such little brooks feed, you may have power in large units for the largest manufactures and the most extensive industries.

"Private capital cannot do these great things as they should be done, for it cannot command capital at low rates of interest, and it is as important in this work to conserve capital as to conserve water. After some great object lessons have been developed by the State, private capital will be less timid. Some large developments privately made have been financially so disastrous as to thoroughly discourage private initiative, as note the early history of the large New England water powers, and later at Massena, N. Y., which failed in that it made provision for the development of the power, but made no provision for its utilization and was at the mercy of the highest bidder for its power and so fell into the hands of the latter.

"On the other hand, the nation can command cheap capital by its standard credit; can put the excess power of its early development to crushing stone, etc., for building roads and for other public utilities, and stand without strain the transition till more valuable markets for power are developed."

Mr. Taylor referred to the possibilities of the Susquehanna River and emphasized "the importance of each stream being comprehensively developed as a single interest, the unit system being the only real solution of the great problem of forestry, water conservation, navigation, and power. And conservation

should extend to every farm brook in the hill country. . . .

"The foresting of hills and the impounding of flood waters is not only the solution of the flood and erosion question, but may be made immensely profitable as well if undertaken with adequate capital and good business sense. But no extravagant prices can be paid for land and water rights required and all concerned must work for the common good.

"Forestry can greatly supplement, but cannot replace impounding reservoirs for the storage of water and the regulation of stream flow. Keeping trees forever in their natural state, leaving them to mature, to die and fall and decay is only a travesty on conservation, and is not worthy of the consideration of an enlightened people."

With large rivers, especially in Europe, the question becomes international, "and if undertaken in the magnitude and importance the subject deserves, it would solve the everlasting peace of all Europe. It ought to be incorporated into international law that the nation that should destroy the conservation works of another should be compelled to pay a penalty equal to five or 10 times the damage done. Babylon is what it is to-day largely because of the destruction of its irrigating system in times of war."

Finally, Mr. Taylor paid a tribute to electrochemistry as a user of power. Twenty years ago electrochemistry as a user of power was unknown, but at this time it is one of the large and constant users of power, in decomposition by wet methods, in chemical manufacture, and electric smelting. The wet methods were first to start, and have made constant and rapid advances. Electric smelting is advancing by rapid strides, and it is predicted, by some most competent to judge, that the electric smelting of iron is already so promising as to make certain the use of enormous quantities of power for these uses alone.

Mr. Taylor's lecture was listened to with greatest interest and at the end it was proposed that a special day should be set aside or a special section organized to discuss these matters at the next congress.

Electric Furnaces.

Mr. F. A. J. FitzGerald, at Niagara Falls, N. Y., read a synopsis of all the papers on the use of the **electric furnace in the iron and steel industry** presented at the recent Niagara Falls meeting of the American Electrochemical Society and reviewed at length in our last issue. He also read a paper on the Lash process. There were also presented several papers by Keller and Gin relating to this subject.

A paper by Mr. Rudolf Taussig discussed large electric furnaces, especially for the **carbide industry**. According to Dr. A. Helfenstein, the maximum load for a compact electrode bundle in continuous operation is 2500 kw to 3000 kw, or 30,000 amp to 40,000 amp, as 75 volts to 90 volts, for a three-phase furnace; this means a total load of 7500 kw to 9000 kw, or 10,000 hp to 12,000 hp in the furnace.

With calcium carbide this development has been pushed even further in the construction of double three-phase furnaces, in which six (instead of three) electrode bundles, that is, two separate three-phase units, are placed in the same channel.

The above figures represent at present the practical limit on account of the very high temperature which necessitates special protective devices for the workingmen and the current-carrying cables, etc. There is further trouble due to smoke, and considerable difficulty in carrying out the charging operation.

It becomes of steadily increasing importance to utilize fully the calorific value of the furnace gases. In order to catch the gases with their high CO content it is necessary to build the furnaces gas-tight. The gas-tight construction of some recent designs of Dr. Helfenstein were explained by Mr. Taussig with the aid of illustrations.

Prof. S. A. Tucker's paper on the relative efficiencies of arc and resistance furnaces for calcium carbide manufacture covered the same ground as his recent American Electrochemical Society paper on this subject. (See our June issue, page 280.)

Caustic Soda and Chlorine.

Quite a number of interesting papers, though not all presented before Section X, related to this industry.

Dr. LEO BAEKELAND, Yonkers, N. Y., gave an account of three years' experience with the Townsend cell at Niagara Falls. This paper is printed in full elsewhere in this issue.

Messrs. F. J. DONNAN and R. FINLAY discussed the electrolysis of brine with the Finlay cell, which was described in and illustrated in our last issue, page 247.

The influence of electrolysis on the alkali industry was the subject of a paper presented by Prof. B. LEPSIUS, director of the Chemische Fabrik Griesheim-Elektron. The paper covered much the same ground as the speaker's lecture abstracted in our May issue, page 189, dealing especially with the electron diaphragm process and comparing it with mercury cathode and gravity processes.

"Passing to a review of the general position of the alkali industry, Professor Lepsius pointed out that the ammonia soda process of Solvay (1857, introduced into England by Ludwig Mond) had severely shaken the paramount position of the old Leblanc process, as supplemented by Deacon and Weldon, which was so strong because so remarkably cyclic. The weakness of the ammonia-soda process was that the chlorine which Le Blanc gained as hydrochloric acid was converted into calcium chloride—of little value. Hence, the chances of the electrolytic processes; the electrolytic chlorine is utilized in organic and inorganic chemistry, and the hydrogen which was first allowed to escape, now serves for welding and for filling balloons; 60,000 cu. m of hydrogen are gained every day at Bitterfield, and partly compressed to 150 atmospheres. About 33,000 hp are utilized in different countries in working Griesheim-Elektron cells to yield 40,000 tons of caustic soda and 45,000 tons of chlorine; one-third of the caustic alkali production of the world is prepared by the Griesheim process; the other electrolytic processes supply together about one-sixth, and the hundred years' giant, the Le Blanc process will succumb. These figures will probably be questioned." (London *Engineering,* June 4.)

Information on the Castner-Kellner process was given in Section V in a paper by RUDOLF TAUSSIG. The old Castner-Kellner cell had been rocked; the current strength had been limited to 500 amp, and mercury had been oxidized.

The second type of cell is the more interesting. The three compartments (chlorine now in the middle) are connected by syphons, and compressed air forces the mercury into the lateral compartments. The anodes, grids of platinum netting, 2 in. square, weighing 1 gram each, and fixed in little mercury cups of glass, are contained in diaphragm boxes of cement; each cell contains six boxes with 88 nets each, and the 528 electrodes take 4000 amp.

The cathodes are cast-iron grids. The iron shunt in the cathode compartment, which is now common property, is required because in the impoverished solution mercury ions would take part in the conduction and be oxidized if the decomposition of the amalgam were not rapid.

In the Kellner-Solvay cell (used in Belgium and elsewhere) the mercury is circulated over an overflow with the aid of a wheel; the current strength can be raised to 10,000 amp, and even 15,000 amp. In the most recent Kellner type this wheel had been replaced by an Archimedean screw, without securing any advantage, however.

*   *   *

A paper by Mr. G. KOLLER dealt with the **utilization of electrolytic chlorine.** Large quantities of electrolytic chlorine are produced by many of the more recent electrochemical processes. In many cases a remunerative commercial outlet has been found for this with some difficulty, and various proposals have been suggested for its utilization.

"Of these, one of the most feasible is the production of solvent liquids formed by allowing the gas to react chemically with acetylene. In this manner two allied processes benefited.

At the present time practically all anhydrous materials used for extracting oil, fats, resins, and similar substances are inflammable, and many are highly explosive. Elaborate precautions are necessary therefore to prevent dangerous outbreaks of fire. Many restrictions are imposed by authorities, transportation companies, and insurance companies, which make it impossible in some cases to work many industries on anything like a profitable scale.

"The chief feature of these **chlorine compounds of acetylene** is that they are non-combustible and non-explosive solvents with a wide range of boiling points. Their use ensures absolute safety and combines the advantages of lower freight rates with a total absence of vexatious restrictions. This subject was received with great interest. In the discussion that followed it was objected that all these chlorine compounds are more or less narcotic in their action on animal life. This is perfectly true, but the property under discussion is not a very active one, and the danger arising therefrom is not as great as that from the average patent medicine." (London *Electrical Review,* June 4.)

*   *   *

The use of chlorine for **detinning tin scrap** was discussed in a paper by Mr. ELMER A. SPERRY, of New York. The paper gives numerous practical considerations that have been developed in the practice of chlorine detinning. It has to do with the preparatory treatment of the scrap prior to the reaction period. This consists in billeting the scrap under peculiar conditions; practicable densities and the reasons found for the operations are clearly stated throughout. It also has to deal with the drying of the scrap and clarification thereof prior to detinning.

In connection with the reaction step proper, there are discussed a number of practical considerations which have forced themselves upon the operator, especially under the conditions of treating large quantities, such as opening up the interstices of the scrap for greater penetration of the reagent; also means which have been found for considerably increasing the depth and penetration of the chlorine, resulting in a higher percentage of purity of the resulting black scrap and a definite lowering of the residuary tin content therein.

A discussion is given of the various means of accomplishing this, such as centrifugal stress and varying the temperature of the scrap. The phenomena of the sudden rise of temperature is also treated and the correct temperatures stated, and means for equalizing and controlling these temperatures to bring about the most rapid performance of the process.

Under the heading of treatment of the resulting black scrap, the discussion is taken up under the heads of removal of the tin chlorides, the removal of the iron chlorides, and also a simple electrolytic treatment which has been found effective in removing the last traces of the acid radical, and thereby creating a true alkaline and perfect weathering scrap.

Further, the question is discussed of the subsequent treatment of the tin chloride in purifying and preparing it for the market, also methods of handling, storing and transporting same.

Another paper by Mr. ELMER A. SPERRY discussed new uses to which refrigeration has been put in connection with liquefaction of gaseous chlorine; also the processes that have been found in practice to successfully cope with the problem of liquefaction of dilute chlorine, where the dilution consists of both foreign gases and moisture and where the amount of diluent present is considerably in excess of that admissible in the liquefaction process heretofore practised. The paper also deals with means of denuding foreign gases and air of such chlorine content as they may possess prior to the ejection of such gases from the plant to the outer atmosphere.

Fixation of Atmospheric Nitrogen.

Hofrat Prof. A. BERNTHSEN, of the Badische Anilin und Soda Fabrik, presented an interesting lecture, with experi-

mental demonstration, on the new **process of the Badische Company,** invented by Dr. Schoenherr, which was described in detail and illustrated in our last issue, page 245. For the description of the electric furnace process itself, the reader must be referred to our former description, as Professor Bernthsen's paper contains nothing new. We, therefore, abstract only those parts of the paper which deal with the chemical methods of working up the nitrogen oxide-air mixture into marketable products.

The absorption at Notodden is at present carried out according to the "acid" process; the first product is dilute nitric acid, which is subsequently converted into calcium nitrate. The apparatus necessary is very extensive, on account both of the small contents of nitrogen oxide in the gases, and also of the very large volume of the gases treated.

The hot gases, on leaving the electric furnace, are first made to pass through boilers, thereby giving up some of their heat, and creating the supply of steam used for heating the vacuum pans, in which the solutions of calcium nitrate are evaporated. These vacuum pans can be heated directly by the furnace gases if desired, or by the intermediate agency of steam.

These gases are then still further cooled and afterward passed into a large empty tower or other receiver, in which time and opporunity are given for the nitric oxide to be oxidized to nitrogen tetroxide. If the gases contain 2 per cent of nitric oxide, 12 seconds are required for the oxidation of 50 per cent of it, while the oxidation of 90 per cent requires 100 seconds. The gases are then passed into very large granite towers, about 65 ft. high, and filled with lumps of quartz, and in these towers the acid absorption is effected by means of water, or of the dilute nitric acid which is collected at the bottom of the tower. In order to recover the oxides of nitrogen which remain unabsorbed, the gases are finally treated with milk of lime or soda, and give rise either to a mixture of nitrite and nitrate or to pure nitrite.

The more dilute the gases are, the more difficult is the absorption, and consequently the greater concentration of the gases is obtained by the process of the Badische Anilin und Soda Fabrik constitutes a not unimportant advantage over Birkeland and Eyde's process. It is stated that the gases leaving the Schoenherr furnace contain about 2 per cent of nitric oxide, that is, they are from one and a half times to nearly twice as concentrated as the Birkeland and Eyde process.

More recent experiments at the Badische Anilin und Soda Fabrik have shown the possibility of effecting the absorption directly with milk of lime, and in this case, the "acid" absorption could be dispensed with, and the absorbing towers and the initial outlay on the plant considerably reduced.

The calcium nitrate obtained by any of these operations can, without further treatment, replace Chili saltpeter for purposes of agriculture, and is in some cases even better. Even a mixture of calcium nitrate with nitrite and free lime appears to have no harmful effect. Such operations as these require abundant and cheap water power.

Considerable quantities of air saltpeter will shortly be put on the market and probably, within a few years, the annual output on the market will reach 100,000 tons.

* * *

A paper by Mr. S. Eyde, one of the inventors of the **Birkeland-Eyde process,** should also be noticed in this connection, although it was presented before the Royal Society in London and not before the congress. We reproduce here those parts of Mr. Eyde's paper which deal specially with the working up of the gas mixture into nitrates.

The temperature of the Birkeland-Eyde flame exceeds 3000° C., or perhaps 3500° C. The temperature of the escaping gases may vary between 800° and 1000° during ordinary working. The furnaces are made of cast steel or iron, the middle of the furnace being built out to a circular flame chamber. The electrodes are led radially into this flame chamber. By aid of centrifugal fans, the air is brought into each furnace through tubes from the basement.

When the air in the flame chamber has been treated by the electric flames the nitrous gases formed pass out through a channel built along the casing of the furnace and thence out through the lower part of the furnace to two fireproof gas-collecting pipes, about 2 m in diameter, which convey the gas through the basement out to the steam-boiler house.

In the boiler house, the gas passes through four steam boilers, in which the temperature, which was, as mentioned, 1000° C., is reduced. The heat given off by the gas is used for concentrating the products, and in the winter time for warming the factory buildings. The steam produced in the boilers is utilized in the further treatment of the products. In the boiler house there are also two large and two small air compressors, which supply compressed air for pumping acids and lye in the factory's various chemical departments.

The gases pass on from the steam boilers through an iron pipe into the cooling house with the object of completing the cooling commenced in the steam boilers. This cooling is necessary in order to obtain a suitable absorption. Each cooler consists of a number of aluminium tubes, over which cold water runs, while the hot gases pass through them. The temperature of the gas is considerably reduced. From the cooling chambers the gases go on to the oxidation tanks.

These oxidation tanks are vertical iron cylinders lined with acid-proof stone. The object is to give the cooled gases a sufficient period of repose, in which the oxidation of the oxide of nitrogen may have time to take place. The necessary amount of oxygen is present in ample quantity in the air which accompanies the gases from the furnaces.

From the oxidation tanks the gases are led into the absorption towers. All the towers are filled with broken quartz, which is neither affected by nitrous gas nor by nitric acid. To assist the passage of the gases on their way from the furnaces there are centrifugal fans constructed of aluminium on each row of towers.

The gases enter at the base of the first tower, go up through the quartz packing, and thence a large earthenware pipe, enter the top of another tower, through which they pass downward through the quartz to the bottom of the third tower, and so on until the air, relieved of all nitrous gases, leaves the last tower. Water trickles through the granite towers, and this is gradually converted into a weak nitric acid, while the liquid used in the wooden towers is a solution of soda.

The absorbing liquid enters the top of the tower and is distributed in jets by a series of earthenware pipes, so that the permeating gases come in immediate contact with the absorbing liquid. In the granite towers nitric acid is thus formed and in the wooden towers a solution of nitrate of soda.

The liquid emerges in a constant, even stream from the bottom of the towers, that from the granite towers running into a granite cistern. Hence it flows into the montejus, which serve to pump up the acid, which has to pass repeatedly through the tower before it has become strong enough for the purpose for which it is intended. The "montejus" are of stoneware strengthened with iron shields; are worked by compressed air, and send the acid up into large stoneware jars.

From these jars the acid again runs through the towers as described. The montejus work automatically. The wooden towers are percolated, as already mentioned, by a solution of soda, otherwise the whole process is practically similar to that in the granite towers.

The solution of soda, owing to its far greater power of absorption, effects the separation of the last remains of nitrogenous gases from the accompanying air. Of the entire quantity of nitrous gases passed through the absorption system about 97 per cent is absorbed.

The finished nitric acid coming from the towers, which has a strength of about 30 per cent by volume, is collected in granite cisterns, from which it is drawn to what is called the "dissolu-

tion works." These consist of granite vats filled with limestone, over which the acid is poured. This drives off, with violent effervescence, the carbonic acid contained in the limestone while the nitric acid takes its place and forms a solution of nitrate of lime or calcium nitrate in water. This solution is now pumped into vacuum evaporating apparatus. The object of boiling in vacuum is the well known fact that great saving is thereby effected in the heat required.

The steam required for the evaporation is obtained from the steam boilers, heated, as before mentioned, by furnace gases. The concentration of the nitrate solution in the evaporizing plant is continued until the specific weight of the liquid at a given temperature shows a content of 13 per cent of nitrogen.

This solution is then sufficiently evaporated, and can be pumped up into the solidification chambers. These are fitted with shallow iron pans, under which cold air is pumped to accelerate cooling. After some time the nitrate stiffens into a brittle, crystalline mass, hard as stone. This is broken up into lumps and is taken into the crushing machines. These consist of ball mills, which reduce the mass to a granular state. The coarse powder so produced is raised by elevator to a vat, from the bottom of which it is tapped into casks holding 100 kg, net weight.

The barrels are made at the company's own cooper shops and are lined with paper to guard against damp. The color of the product depends on the limestone used in the manufacture. The nitrate of lime is used in various chemical works, as well as for manure, the only difference being that, for the former purpose, the product is not ground fine, but is run direct in the liquid state into thin iron drums in which it stiffens into a solid mass.

As to the further treatment of the nitrate formed in the alkaline towers, when this is pumped away from the towers and water, also some nitrate of soda and bicarbonate.

The further process is designed to separate the pure nitrate from the other substances. This is accomplished by first boiling away some of the water, which is done, as in the case of the nitrate solution, by steam from the steam boilers, heated by the furnace gases. The nitrite solution, concentrated to a suitable boiling state, is run into crystallization pans, in which the crystallization of the nitrite takes place.

The crystals are separated by centrifugal means and are conveyed by a screw transporter to a drying apparatus, where they are subjected to a current of hot air. The finished product is then run into casks containing 300 kg each. This nitrite of soda is used as the raw material in the manufacture of certain kinds of aniline colors. The manufacture of nitrite is carried on in a special building.

In the enire process of manufacture, both of nitrite and nitrate, no coal is used; all the machinery is worked by electric power, and for heating and evaporating the nitrate and nitrite solutions, the only steam employed is that obtained by the hot gases passing through a system of steam boilers.

Moreover, this industry is not confined to the two products hitherto mentioned—nitrate of lime and nitrite of soda—but there are possibilities for the development of a whole series of new industries, of which Mr. Eyde specially named the production of nitric acid and nitrate of ammonia, nitrate of potassium, and others. They have succeeded, in conjunction with the Nobel (nitroglycerine, etc.) Syndicate, in concentrating their weak acids by means of gases from their furnaces to acids of high percentage, which can be transported.

In a paper presented before the congress by Prof. BIRKELAND, the other inventor of the **Birkeland-Eyde process,** some further interesting details were given. They are now building 1600-kw furnaces instead of the 800-kw units, of which 35 are run at Notodden, eight in series; the air enters the flame disk through a number of perforations arranged in circles on radial lines in the furnace walls. The 1600-kw flame disk has a diameter of 2 m and a thickness of about 10 cm. Currents of 500 amp are starting from points on the tubular copper electrodes not more

than 1 mm in diameter, and those partial arcs which are constantly spreading out and breaking off are not steady for more than 0.00001 second.

* * *

The **calcium cyanamide** industry was discussed in a paper by Dr. NIKODEMUS CARO, of Berlin, on "The Nitrolim Industry and Allied Industries." Since we have discussed many times in the past the production of calcium cyanamide or nitrolime from calcium carbide and nitrogen, only a few new interesting details from Dr. Caro's paper shall be abstracted here from London *Eng'ing,* June 4.

He first referred to the influence of the impurities contained in the carbide—features of considerable industrial importance. Ordinary calcium carbide contains lime, sulphides, phosphides, carbon and other impurities, and their presence and physical properties influence the absorption of nitrogen so much that carbide of the same composition, but made in different types of furnaces, may behave very differently in the nitrolime furnace.

The second raw material of the process, the nitrogen, should not contain any other gases or water. Linde apparatus supplies a suitable nitrogen; but as they are somewhat expensive, the older process of binding the oxygen of the air by means of copper, which is burned to oxide leaving the nitrogen, is also applied; the copper is afterward reduced again.

Dr. Caro made an interesting announcement in this connection. He has succeeded in isolating nitrogen from the combustion gases of producer gas. He conducts these gases through a mixture of copper and copper oxide, which absorbs oxygen and carbon monoxides, and thus obtained a mixture of nitrogen and carbon dioxide, the latter is absorbed by alkali carbonate solution, which binds the CO_2 more readily if the oxygen and other gases have previously been removed.

The nitrogen has to be free from water, and also from CO and CO_2, because these gases react with calcium carbide with liberation of carbon; they also destroy the cyanamide already formed (the cyanamide formation being a reversible process $-CaC_2 + N_2 = CaCN_2 + C$).

With a carbide of 82.3 per cent of CaC_2 (calcium carbide) and 14.7 per cent of CaO (lime) the temperature above which the already formed cyanamide is decomposed into nitrogen and carbide again is 1360° C.; in the presence of more carbide decomposition begins at lower temperatures.

Owing to this reversibility the process of carbide and nitrolim manufacture cannot be made continuous; the cooling carbide becomes impervious to nitrogen, and has hence to be ground up and reheated for absorbing the nitrogen. Now, although the combination of CaC_2 and N takes place with the evolution of heat, that heat is not sufficient to continue the process when cold nitrogen and cold carbide are fed into the furnaces, the more so as the specific heat of carbide increases from 0.243 at 0° C. to 0.288 at 1200° C. The furnaces have hence to be heated; but if the heat were applied from outside, the temperature would rise too high on the walls and decompose the formed cyanamide. The heating is, therefore, effected in the mass itself in heat-insulated furnaces by means of electrically heated rods of carbon; after a while the heating can be interrupted, and will proceed automatically, all the more readily the purer the carbide.

For this reason the above-mentioned additions to the carbide are undesirable as ballast to be heated. The total amount of electric energy is small, being only 3 hp-years per ton of nitrogen bound as cyanamide. A factory commanding 12,000 hp can produce 20,000 tons of nitrogen lime per year, corresponding in nitrogen contents to 20,000 tons of ammonium sulphate and 25,800 tons of Chili saltpeter. Large works are, hence, rising, mostly relying on water power; those at Knappsack and Westeregeln burn lignite, however.

Some other abstracts of congress papers will be found in the Synopsis of Current Literature in this issue. All members of the congress will receive the complete *Transactions* in due course.

Calculations in Ore Concentration.

An interesting paper, of marked originality, was recently presented by Dr. RUDOLF GAHL, electrochemist and metallurgist of Morenci, Ariz., before the Colorado Section of the Western Association of Technical Chemists and Metallurgists. In this paper Dr. Gahl discusses simple mathematical calculations as a means of getting as much useful and practical information as possible from screen tests and assays in ore concentration. The paper is published in full in the April issue of the organ of the association, the *Western Chemist and Metallurgist*. In the following the paper is reprinted almost in full.

The size of American concentrating plants, especially of those treating copper ore, has very greatly increased in recent years. When we consider the enormous sums of money represented by the ore treated in these plants and how great might be the financial loss due to slight errors in mill operation, the necessity of keeping close watch on the work becomes apparent.

It is not possible to so thoroughly control a plant of this kind as it is to regulate, say, an electrical central station, where a number of ammeters and voltmeters will indicate precisely the operation of the plant. The best indicators which the concentrating man has at his command are screen tests and assays, but a great deal also depends on his ability to interpret properly the readings of these indicators. To do this successfully requires the application of some mathematics.

Assays.

Dr. Gahl first discusses what information can be obtained from assays of heads, concentrates, and tails, regarding the saving which a concentrator is making.

Let one ton of ore be put into the mill, and let y and z (fractions of one ton) be the respective weights of concentrates and tails produced from 1 ton of ore. The assays of ore, concentrates and tails may be designated as a, b, c, respectively. For instance, a concentrator operating on 3 per cent copper ore may produce concentrates carrying 17 per cent Cu and tails with 0.7 per cent Cu. In this case we have $a = 0.03$, $b = 0.17$, $c = 0.007$.

Then the two facts, that the weight of ore equals the combined weights of concentrates and tails, and that the amount of copper or other valuable constituents in the ore equals the combined amount of copper in concentrates and tails, are expressed by the two equations:

$$1 = y + z \qquad (1)$$
$$a = by + cz \qquad (2)$$

If z is eliminated from these equations we get,

$$y = \frac{a - c}{b - c} \qquad (3)$$

Now y is the weight of concentrates produced from 1 ton of ore. We will get the saving by dividing the amount of copper in the concentrates (by) by the amount of copper in the 1 ton of ore (a) so that the saving S is

$$S = \frac{by}{a}$$

Substituting this deduced value of y in equation (3) we get the following equation for the saving,

$$S = \frac{b(a - c)}{a(b - c)} \qquad (4)$$

This formula contains no weights and it is clear, therefore, that the saving of a concentrating plant may be calculated from the assays of the ore, concentrates, and tails, without knowing anything about the quantities used or obtained.

For example, for the numerical example noted above this formula gives $S = 0.8$; or, in words, the saving of the concentrating plant is 80 per cent.

In plants where ore and concentrates are weighed (the weight of the tailings being taken by difference) the results of this formula can be checked against the saving calculated by other methods. There are three more possibilities, which in our terms are as follows:

$$S = \frac{by}{ax} = \frac{\text{copper in concentrates}}{\text{copper in ore}} \qquad (5)$$

$$S = \frac{by}{by + cz} = \frac{\text{copper in concentrates}}{\text{copper in concentrates and tails}} \qquad (6)$$

$$S = \frac{ax - cz}{ax} = \frac{\text{copper in ore minus copper in tails}}{\text{copper in ore}} \qquad (7)$$

If the weights and assays are all correct, these four methods should check. In practice, of course, they do not check exactly. An example of the results obtained by the four methods in a certain copper concentrator, for several consecutive months, is as follows:

Method of calculation.		Saving.	
(1) Assays only	77.48	78.59	80.33
(2) Weights and assays of ore and concentrates	78.09	80.73	79.00
(3) Weights and assays of tails and concentrates	77.64	79.11	80.02
(4) Weights and assays of ore and tails	77.52	78.69	80.27

These four methods of calculation are not independent of each other. If the amount of copper in the ore as calculated from weights and assays equals exactly the amount of copper in concentrates and tails as calculated from their weights and assays, all four methods will give the same results; but if there is a discrepancy, the methods will give discordant results. In the latter case it will depend entirely on specific conditions which method is the most trustworthy, whether, for example, one sample is more reliable than another, or whether the weights can be relied upon, etc.

In the derivation of the formula for the saving calculated from assays only, equation (3) was quickly passed over, but it has special interest:

$$y = \frac{a - c}{b - c}$$

Since y means that fraction of the ore which makes up the concentrates, it is equivalent to what is spoken of as the "rate of concentration." For instance, in our previous example of an ore carrying 3 per cent copper, and giving concentrates carrying 17 per cent of tailings of 0.7 per cent copper, we would find for y the value of 0.141, or expressed as a common fraction $\frac{1}{7.09}$. This is equivalent to the statement that 7.09 tons of ore have produced 1 ton of concentrates, or that the ore has been concentrated 7.09 into one.

This equation is also interesting from another standpoint. The rate of concentration is expressed by the assays of the ore, concentrates, and tails; but in deriving this equation we made no assumption as to the kind of assays which it represents. Therefore, it will evidently hold true for copper, gold or silver assays, or for any other set of chemical determinations. All of these determinations cannot, of course, be made with equal exactness, and when we have a practical problem of determining the rate of concentration from a set of assays, such determination will be chosen as are most reliable.

On the other hand, the fact that the rate of concentration can be calculated in so many ways, permits us to eliminate y and compare the different assays directly. If, for example, a, b, c, represent assays for gold; a_2, b_2, c_2, assays for sulphur, and a_3, b_3, c_3, assays for iron or any other constituent in ore, concentrates, and tails, respectively, the relations will hold true thus:

$$\frac{a - c}{b - c} = \frac{a_2 - c_2}{b_2 - c_2} = \frac{a_3 - c_3}{b_3 - c_3} \text{ etc.} \qquad (5)$$

Dr. Gahl remarked that he had not at hand any assays to show the application of this equation, but it is clear that it will allow the calculation of a complete analysis of the tailings if a complete analysis of the ore and concentrates and only one assay of the tails be given.

Screen Tests.

What is the additional information which can be obtained from screen tests?

Take, for example, a problem of this kind: A certain concentrator disposes of its tailings in the following manner: After classification in cone classifiers, the spigot discharge contains the coarse sand with a little water, and is used to build a dam across the mouth of a gulch adjoining the tailings end of the plant. The overflow is conducted into the basin thus formed, where the suspended solid matter settles, liberating clear water, which is again used in concentrating. The question arises: what percentage of the tailings goes to the dam and what percentage to the pond? This problem can easily be solved by making some sizing tests on the general tails and the two products of classification mentioned.

Let the total quantity of the tailings be I ton, that part going to the dam be y, and the portion going to the pond be z. Then we have the equation,

$$1 = y + z \qquad (6)$$

If we screen the samples of each material on, say, a 100-mesh screen, we will have a certain fraction of each sample remaining on the screen, which we will call a_{100}, β_{100}, γ_{100}. If we screen a general tails sample we will evidently get the same percentage of 100-mesh material as if we split this sample into the part which builds the dam and the part which feeds the pond, screened these two samples separately and combined the corresponding sizes. This fact is expressed by the equation,

$$a_{100} = \beta_{100} y + \gamma_{100} z \qquad (7)$$

or by elimination of z from (6) and (7)

$$y = \frac{a_{100} - \gamma_{100}}{\beta_{100} - \gamma_{100}} \qquad (8)$$

This equation naturally holds true for any other screen size and if we screened on a 200-mesh screen we would have,

$$y = \frac{a_{200} - \gamma_{200}}{\beta_{200} - \gamma_{200}} \qquad (8)$$

The screen to be used in a given case depends, of course, on the material to be screened, the principal point to be observed being the screen which will give the most exact results. It is to be understood that screening does not give absolutely exact results, for no screen is absolutely uniform; but those who have made wet-screen tests often enough to become proficient will admit that screening on fine sizes, say, from 100-mesh down, is fairly accurate. Although the error in screening expressed in percentage may be greater than the error in assaying, there are cases in which the results based on screen tests are much more reliable.

In the case under consideration the screen tests were as follows:

	General tails.	Tails to dam.	Tails to pond.
Percentage on 100-mesh	44.4	75.2	3.1

Substituting the screen results on 100-mesh screen in our formula we find that 57.3 per cent went to the dam and the balance of 46.7 per cent to the pond.

This problem could have been solved from the assays only. The same set of examples used for the screen test was assayed with the following results:

	Cu per cent.
General tails	0.85
Tails to dam	0.72
Tails to pond	1.16

Our formula (3) will solve this problem. Although we have deduced this formula for relations existing between ore, concentrates, and tails, it holds for any case in which one product is split into two other products, or where two different products are combined into one. Dr. Gahl emphasizes the fact that the two products into which one is split, or which are combined into one, must be different, for if they are the same the

problem cannot be solved, and if they are nearly alike, the error in the result will be great. Therefore, if there is but little difference in the assays of the products, screening will give better results, but if the material is of practically the same size the assays should be the basis of the calculations.

Returning now to the dam problem, let a represent the assay of the general tails, b the assay of the coarse tails, and c the assay of the fine tails; y will represent the fraction of the tails going to the dam. Using these assays in the formula we get $y = 70.5$ per cent.

This is decidedly different from the figure 57.3 per cent which we obtained from the screen tests, and is evidently not reliable. This is due to the fact that the differences between the assays of the three products are so small that they are not a safe basis of calculation. This then is a case where screen tests give much more reliable results than assays.

That the assays are really conformable with the screen tests can be shown by calculating the assay of the general tails from the assays of the coarse tails (dam) and the fine tails (pond), making use of the proportion between the two found by screening. The calculated general tails assay, according to this, would be,

$$a = bx + cy$$

$$a = 0.91 \text{ per cent Cu.}$$

This checks the actual assay within the limits of the ordinary cyanide assay for copper, and shows that the results by assaying have not contradicted the results obtained by screening.

But we are able to solve this problem in still another way, by considering the percentage of water carried by each one of the materials in question. We have the equation for the dry pulp,

$$a = b + c \qquad (9)$$

If we call the weights of the wet pulps A, B, and C, respectively, the following equation is also true,

$$A = B + C \qquad (10)$$

If a, β, γ, represent the percentages of solid matter in A, B, and C, respectively, we will have the following equations,

$$a = A a \qquad (11)$$
$$b = B \beta \qquad (12)$$
$$c = C \gamma \qquad (13)$$

Substituting these values in equation (10) it follows:

$$\frac{a}{a} = \frac{b}{\beta} \times \frac{c}{\gamma} \qquad (14)$$

Since it is again unessential what quantities we consider, we will make $a = 1$. Then

$$1 = b + c \quad \ldots \ldots \quad c = 1 - b \qquad (15)$$

$$\frac{1}{a} = \frac{b}{\beta} \times \frac{c}{\gamma} \qquad (16)$$

By eliminating c from the two equations we get,

$$b = \frac{\beta(a - \gamma)}{a(\beta - \gamma)} \qquad (17)$$

The moisture samples taken gave the following results:

$$a = 13.1 \text{ per cent solids.}$$
$$\beta = 42.5 \quad `` \quad `` \quad ``$$
$$\gamma = 6.9 \quad `` \quad `` \quad ``$$

By substituting these figures in our equation we find

$$y = 56.5 \text{ per cent}$$

which represents the percentage of dry tailings that would go to the dam. This checks the results which we obtained from the screen tests, which was 57.3 per cent.

It seldom happens, however, that problems in the distribution of pulp are as easy as this one. If three products are combined into one, or one is split into three, the calculations are more complicated. For example, a concentrator produces three final tailings products, by the following treatment: the coarsest ore is treated on Wilfley tables, the next finer on one set of vanners, and the finest set on still another group of

vanners. The tailings from all three sets of machines are combined into general tails. The question arises: what percentage of the general tails originates from the Wilfley tables, and what percentage from each set of vanners? This question could be solved by screening the different tails samples. Let us call

a_{30} the fraction of general tails remaining on 30-mesh screen,

b_{30} the fraction of Wilfley tails remaining on 30-mesh screen.

c_{30} the fraction of first vanner tails remaining on 30-mesh screen.

d_{30} the fraction of second vanner tails remaining of 30-mesh screen.

a_{200} the fraction of general tails remaining on 200-mesh screen, passing 30-mesh.

b_{200} the fraction of Wilfley tails on 200-mesh screen, passing 30-mesh.

c_{200} the fraction of first vanner tails on 200-mesh, passing 30-mesh.

d_{200} the fraction of second vanner tails on 200-mesh screen, passing 30-mesh.

β the fraction of Wilfley tails in general tails.

γ the fraction of first vanner tails in general tails.

δ the fraction of second vanner tails in general tails.

Actual screening showed that only a portion of the general and Wilfley tails remained on the 30-mesh screen, and the vanner tails contained only negligible portions of such material. This furnishes the equation,

$$\beta b_{30} = a_{30}$$

from which β can be calculated.

For the screenings passing through 30-mesh and remaining on 200-mesh, the following equation will hold true,

$$\beta b_{200} + \gamma c_{200} + \delta d_{200} = a_{200}$$

But according to our assumption,

$$\beta + \gamma + \delta = 1$$

and by eliminating δ we get

$$y = \frac{a_{200} - d_{200} - \beta\,(b_{200} - d_{200})}{c_{200} - d_{200}}$$

The actual screen tests for one day were as follows:

$a_{30} = 17.7$	$a_{200} = 36.8$
$b_{30} = 40.7$	$b_{200} = 53.9$
	$c_{200} = 44.0$
	$d_{200} = 9.3$

The calculation gives the following results:

$$\beta = 43.5 \text{ per cent}$$
$$\gamma = 23.3 \text{ " "}$$
$$\beta b_{200} + \gamma c_{200} + \delta d_{200} = a_{200}$$
$$\beta + \gamma + \delta = 1$$

The elimination of γ furnishes the equation,

$$\delta = \frac{a_{200} - c_{200} - \beta\,(b_{200} - c_{200})}{d_{200} - c_{200}}$$

$$\delta = 23.3 \text{ per cent.}$$

As a check on this calculation $\beta + \gamma + \delta$ may be formed which should add up to 100 per cent.

This may be sufficient to show how similar problems may be solved. If it is necessary frequently to determine what percentage of the total tails originate from the different machines in a concentrator it may be wise to install mechanical appliances for this purpose. At Dr. Gahl's suggestion the Detroit Copper Company has done this in the following way: The tail launders from the different groups of machines are conducted separately to the bottom of the mill. There separate sample slots are provided for the discharge of each launder. These slots are of equal width and are operated by the same mechanism, consequently the samples cut out by them are proportional to the total amount of tailings. It may be mentioned, by the way, that the three stream of tails are combined after passing their respective sampling slots and that a sample of

this general tails product is taken through a slot which is operated by the same mechanism that actuates the three sampling devices mentioned above.

Of course, the assay of the general tails can be calculated from the weights and assays of the three separate tailings samples. The comparison between the calculated and assayed general tailings sample furnishes a check on the work of sampling and assaying.

Distribution of Pulp.

The question may be asked whether it is of so great importance to know how the pulp is being distributed in a mill, and whether the mill man cannot tell from the appearance of his machines whether the distribution is correct. On the basis of a comparison between actual determinations and estimates from appearance of the machines, Dr. Gahl concludes that such estimates are in no way trustworthy.

There is one distribution of pulp which will give the minimum loss and the only question is whether the results obtained by that distribution are sufficiently better than any others to warrant exact determination of the proper conditions.

This is illustrated by Dr. Gahl by reference to a practical
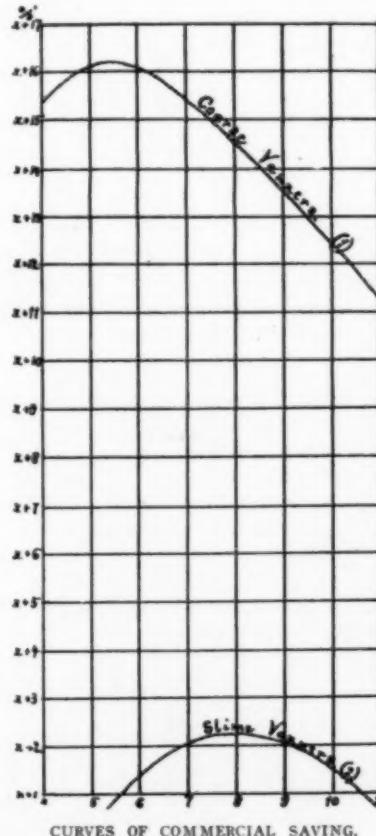
CURVES OF COMMERCIAL SAVING.

case. In a certain concentrating plant two vanner feeds are made. The separation of the two feeds is made in a V-shaped box classifier, in which, however, no hydraulic water is used, so that only a rough classification is made, throwing the greater part of the sand and the smaller part of the slime to the first set and the rest of the sand and the bulk of the slime to the second. The question now arises: how much feed should each set of vanners carry?

Some tests showed that if the best possible saving of copper was desired, only a very small feed should be carried per machine, and that increasing this load increased the loss of metal. But such a policy could not be carried out in a commercial plant as the question of operating cost would enter. An extremely light load would be impossible, for only a relatively small profit would remain after deducting operating

costs, which in the case of a small load would form a serious item.

Dr. Gahl calls "metallurgical saving" the percentage of valuable metal recovered. By deducting from this figure as many per cent as would pay for the operation of the machine, he gets what he calls "commercial saving." Now, the commercial saving if the best, or expressed mathematically, has a maximum, for a greater load. Assuming, for example, a copper value of 15 cents per pound, curves 1 and 2 in the accompanying drawing will represent commercial saving for the coarser vanner feed and the fine vanner feed, the maximum being at 5½ and 8 tons, respectively.

This would mean that the feed should be distributed between the first and second sets of vanners in the proportion of 11 to 16 in order to get the most economical load, and shows the value of a method in guiding the concentrator foreman in the distribution of pulp. In arriving at this conclusion the assumption has, of course, been made that by changing the size of the classifier spigot discharge, the character of the two feeds is not changed. This assumption will always be safe when the existing distribution is not very different from the one found best by the method.

The result indicated, viz., that a vanner treating a coarse feed should receive a smaller load than a vanner treating a slime feed, may seem surprising in view of the fact that a slime table should receive a very small load in order to make a good saving. Dr. Gahl thinks also the fact that a slime vanner carrying its best load will make high tailings and a vanner treating coarse material will produce low tailings, would induce some mill managers to take the feed away from the slime machines and increase the load on the coarse.

Nevertheless, considered from the standpoint of the curves, this would be a mistake. The explanation is that this slime feed contains such a large percentage of what has been called absolute slime, on which concentrating machines cannot effect a saving by any means, that the proportion of copper that can be saved is very small, and would not pay for the operation of the large number of machines necessary to save it. A coarser feed, however, contains only a small percentage of this extremely fine slime, and for this reason the recovery will be high in every case. But even though it may be high already, it may pay to try to increase it by distributing the pulp over more machines.

There is one point that Dr. Gahl emphasizes in this connection: that the tailings assay gives no information regarding the work which a machine or plant is doing. The only criterion is: do the tailings contain values in a form that can be saved by wet concentration? It is not easy to determine this point, and the only place where this determination is attempted appears to be in the concentrator of the Green Cananea Company, Canannea, Mexico. Although the methods in use for this purpose may not be perfect, it would seem that only by adopting some such plan shall it become possible to distinguish between avoidable and unavoidable losses and learn to eliminate the former.

The Calcium Carbide and Cyanamide Works at Odda, Norway.

In our May issue (pp. 212 to 216) a description was given of the general arrangement of the new hydro-electric plant, with calcium carbide and calcium cyanamide works, at Odda, Norway. In the following we give some further details of these works, especially of the carbide and cyanamide works. This article is abstracted from the exceedingly full description which is now being published in serial form in London *Engineering*. The accompanying illustrations are also reproduced from our London contemporary (April 23, May 7 and 28).

Carbide Works.

Besides the methods of transportation and handling of mate-rials, the arrangement of the lime kilns and carbide furnaces is of chief interest.

Lime Kilns.—Each of the five kilns has a capacity of 30 tons, and four of them suffice to supply the calcined lime required for the whole of the 12 electric furnaces, so that one of the kilns is a stand-by. Provision has been made for erecting a second row of kilns parallel to those already in use, to correspond with a duplication of the electric furnace plant, when this is required by the market.

Sections are given of one of the kilns with its gas producers in Figs. 1 to 3. These producers are constructed of brickwork with firebrick lining, and for each of the lime kilns there are four producers, two on each side of the kiln, and each has a
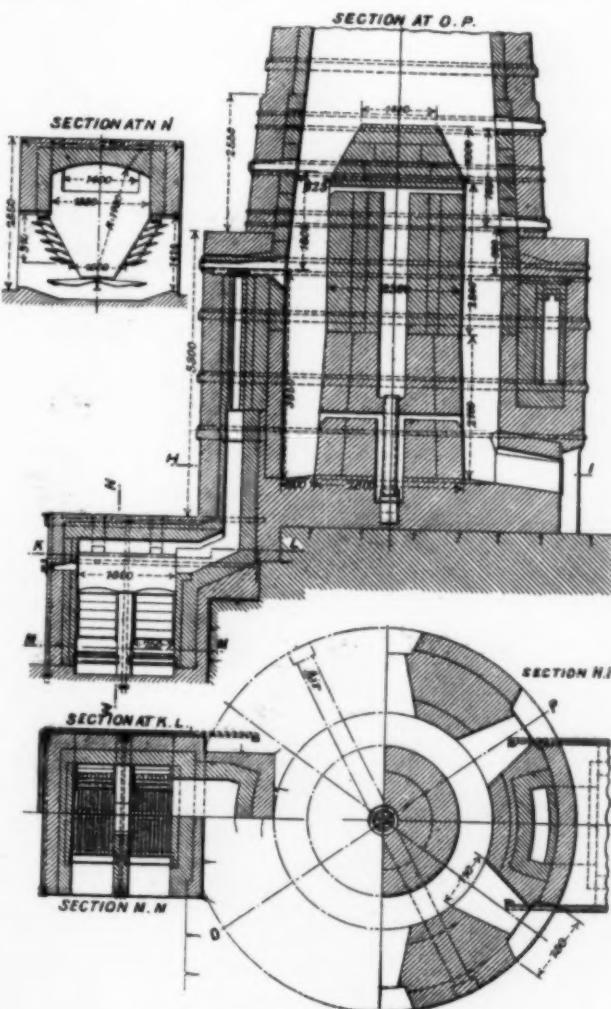
FIGS. 1, 2 AND 3.—DETAILS OF LIME KILNS.

door at each end, making eight doors. The firebars are of cast iron and are constructed as shown in the section, Fig. 3. The bars in two parts, that near the fire is flat, with slight declination toward the fire, while that on the outer side is in the form of a V-channel. Water is fed into the top channel and overflows into the others, and this supplies sufficient vapor.

The coal is charged from the floor level of the kiln house. The kilns are built at 15 m (49 ft. 2.5 in.) centers, and rise to a total height of 24 m (78 ft. 9 in.).

At the top an archway has been formed, 5 ft. 6 in. wide, the products of combustion passing on each side of the archway. The chimney top, which is 3 ft. in diameter, has a cap pivoted on an iron standard, so that by means of a wire extending to the ground level the kiln may be completely closed down.

The limestone wagons for charging the kilns pass through the archway, their contents being tipped into the limekiln

through a hopper fitted with a valve. The level of this charging platform is 14 m (45 ft. 11 in.) from the bottom of the kiln. The diameter of the kiln at the lowest part is 7.1 m (23 ft. 3½ in.), while the inside diameter is 3.150 m (10 ft. 4 in.). The walls are 750 mm (2 ft. 5½ in.) thick.

In the center, as shown in Figs. 1 and 2, there is a brick core with a conical top, leaving a combustion chamber in the form of a ring for the burning of the limestone. In the brick core there is a central passage which is utilized for the passage of air to mix with the gas for combustion.

The uptake for the gases from the producers is rectangular in plan (Figs. 1 and 2) and communicates through a flue in the outer walls of the limekiln with a circular passage around the walls, having 18 small inlets to the interior of the limekiln. These inlets or cavities extend right through the outer wall and are fitted on the outside with manholes, so that, if necessary, firebricks may be inserted for the regulation of the area of opening for the inflow of gas from the vertical flue. The air


FIG. 4.—CHARGING THE LIME KILN.

supply to assist combustion within the kiln is admitted, as already indicated, through a vertical passage in the brick core at the top of which small horizontal ducts pass the air to the combustion chamber.

These air ducts are above the level of the cavities admitting the producer gas. Thus the ascending gas meets a current of air at the top of the ring chamber of the kiln, and at the point past which the limestone falls from the main upper chamber at the top of the kiln into the ring chamber. The point of admixture of gas and air is about 4 m (13 ft. 1½ in.) from the floor of the ring chamber, so that the burned lime is cooled before it reaches the discharge door of this chamber.

Transportation of Materials.—The calcined lime is withdrawn into wagons running on a telpher railway and fitted with 2-hp electric motors. The calcined limestone is taken by these wagons to a crushing mill adjoining the carbide electric furnace house. The lime is discharged into hoppers, which feed, through

transporting bands, the jaw crushers employed for breaking the lime.

The coal from the anthracite silo is conveyed by wagons traveling on a telpher railway, and is discharged into hoppers which feed, through band conveyors, electrically operated jaw crushers to break it into very small cubes for use along with the lime in electric furnaces. In addition to jaw breakers, there are "centrifugal mills" similar to those used for grinding cement.

From these the anthracite or lime is conveyed and elevated for discharge into storage hoppers, and from these the material is drawn as required into an electrical automatic weighing machine, having two compartments. Although the hoppers are of considerable capacity, the discharge spouts are brought close together, and the feature of the ingenious electric appliance is that it is arranged to weigh out the two constituents of the electric furnace charge in their correct proportions, so that there is absolute precision in this respect—a point of considerable importance in ensuring satisfactory results in the production of calcium carbide.

Calcium Carbide Plant.—In the furnace house there are 12 electric furnaces, each of 1400-kw capacity, constructed on the Alby system. "The high degree of efficiency now realized by these furnaces is the outcome of much research, and for obvious reasons" sectional drawings are not given. The voltage is 50, and the current 28,000 amp.

The transformers used are placed in underground chambers under the furnace so as to ensure the minimum length of conductor. The conductors from the switchboard are laid in a tunnel of large area under the ground level, and very powerful fans are fitted near to the transformers. These take their current of air from the tunnels, so that the temperature of the transformers is comparatively low.

The furnaces are charged by hand from adjacent hoppers, replenished from bunkers traveling round the building, from the automatic weighing machine. The furnace charging is practically continuous, and the men are screened from the exceedingly high temperature of 3000° C. (5720° Fahr.) by gauze curtains.

The furnaces are tapped at intervals of about 45 minutes and their capacity is from 7 to 8 tons per day of 24 hours. The carbide is teemed into receptacles (heavy cast-iron trays) 1 m square, which ahe conveyed by electric traversers to the carbide-cooling house, immediately adjoining the furnace house.

The cooling house is 15 m (49 ft.) wide by 27.4 m (90 ft.) long. The cooling frames are built up of iron plates with rails at 12 in. centers, on which the carbide slabs are deposited. The frames are set on a gradient of about 20° from the side walls down to the center of the building, where there is a conveyor traversing the building, and on to this the slab gravitates.

The carbide slab is 6 in. thick, and is almost red-hot when deposited. Openings are left in the wall of the building, and a constant current of air passes over and under the cooling plates, which are perforated at frequent intervals. During the process of cooling the slab of carbide cracks, owing to contraction, and after it has lain for about eight hours the workmen find it easy to break the pieces up, and assist them to glide down the slope, where they fall on to the transporter band, built up of plates and angles, and operated by a 10-hp electric motor.

The band is not continuous for the whole length of the building, but is arranged to deliver the material at both ends of the cooling house, that at one end being intended for the adjacent cyanamide works, where the carbide is converted into calcium cyanamide. At the other end of the building the calcium carbide is delivered for transference by band conveyor to the crushing house, to be reduced to cubes varying in size according to market requirements.

Carbide Crushing and Grinding Plant.—The whole of the system of breakers and conveyors is operated by one 40-hp motor. The carbide is conveyed from the cooling house and deposited into the first two jaw stone breakers on the ground

level (Figs. 5 and 6), where it is broken into cubes of about 4 in. in size.

This crusher discharges the material into a series of small buckets mounted on a wheel which rotates at a rate corresponding to the travel to the conveyor buckets under it, and this the material is fed to the conveyor without any being lost. The conveyor works in combination with an elevator and thus the
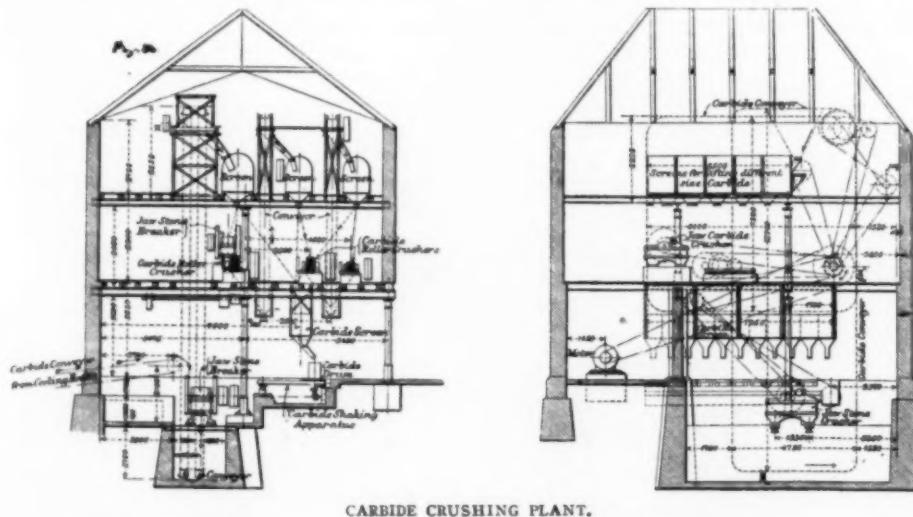
CARBIDE CRUSHING PLANT.

cubes are raised to the top floor and fed through a hopper into a screening machine of the rotary type.

The perforation is of five different meshes, in order that the material may be separated and deposited into five hoppers, according to the size (Fig. 6). The tailings exceeding 80 mm (3.15 in.) fall over the end of the revolving screen and pass to a second jaw stone crusher. This latter is on the intermediate floor (Fig. 6) and deposits the material crushed in the same way as in the instance already described, into a conveyor and elevator, which discharges into a second cylindrical screen on the top floor, where again the material is separated into several sections of varying size.

The tailings over 25 mm (1 in.) pass to a roller crusher on the intermediate floor, and thence by conveyor and elevator to the third of the cylindrical screens, where the material is again separated into five divisions, by means of the screens and hoppers under them, the range being from 1 mm to 15 mm (0.04 in. to 0.59 in.).

Thus the three cylindrical sifting screens have each five receiving hoppers, as shown in Fig. 6, and from each there are independent shoots to the series of hoppers. The carbide of each size is delivered on the packing floor (Fig. 6) without being passed through successive screening and crushing machines to reduce it to the minimum sizes.

By the mesh of the respective sieves, the material is divided into marketable sizes. These are 2 mm, 2 mm to 4 mm, 4 mm to 7 mm, 8 mm to 15 mm, 15 mm to 25 mm, 25 mm to 50 mm, and 50 mm to 80 mm, or ranging from 0.08 in. to 3.15 in. The finished-material hoppers are all of the same size or cubical capacity, but there are two hoppers for the material of the two largest sizes.

The shoots of these hoppers are fitted with a sliding shoe, which can be opened when the terne-plate drums are placed under them. The drums for the reception of the material are placed on an oscillating platform (Fig. 5), which is pivoted at one end, while under the other—under the drum—there is a projection in contact with an eccentric wheel, which when rotated gives the platform a shaking motion. This ensures that the greatest volume of material shall occupy the minimum of space in the drum. It has thus been possible to arrange that the cubical capacity of the drum is only slightly in excess of the volume of carbide for a given weight.

The manufacture of the drums, and of the barrels in which these are encased, is, of itself, an interesting department of the Odda works, as labor-economizing machinery has been introduced with striking results.

The drums are made of terne plates and are of two sizes: to take 100 kg (220 lb.) or 50 kg (110 lb.) of carbide, the diameters being respectively 425 mm (16.73 in.) and 300 mm (11.81 in.), while the height in both instances is 600 mm (23.62 in.). Five hundred of the 100-kg drums are manufactured per day of 10 hours, there being employed 11 boys under 18 years of age, with a foreman, and the total labor-cost is 80 kr., equivalent to 22 cents per drum. For further details of the department for the manufacture of the drums and barrels the reader must be referred to the descriptions in London Engineering, May 7.

Cyanamide Works.

Ten thousand tons of the calcium carbide annually manufactured at the Odda works are utilized in the adjacent cyanamide factory belonging to the North-Western Cyanamide Company, Limited, for the production of this new fertilizer, which contains 20 per cent of nitrogen and upward. The trade name which has been adopted for calcium cyanamide is nitrolime.

Concerning the production of calcium cyanamide much has been published before in this journal; see, for instance, our Vol. I, p. 423; Vol. IV, pp. 136, 327, and especially the paper by Erlwein in our Vol. V, p. 77. The process used at the Odda works is that of Frank and Caro, which starts with calcium carbide and nitrogen as raw materials, the principal reaction being $CaC_2 + N_2 = CaCN_2 + C$.

The process is controlled by the Societa Generale per la Cianamide in Rome, Italy, by whom manufacturing licenses are granted. The British concessionnaires are the North-Western Cyanamide Company, who own the rights for Scandinavia, 30 per cent of Germany, Belgium and all the British colonies excepting Canada. Their works are at Odda, and the plant is typical of the most modern practice in order to secure the economic production of a uniform product containing 20 per cent of nitrogen.

The Odda works are the largest in operation, although others of equal, or even slightly greater, capacity are now being constructed. The following list gives the works in operation, with their annual producing capacity, and those (in the second column) now under construction and contemplated:

Works completed.	Tons.	Works under construction.	Tons.
Odda	12,000	Dalmatia (two factories)	8,000
Briancon	3,750	Italy (two factories)	7,000
Martigny	3,750	Bavaria	12,500
Piano d'Orte	5,000	Niagara	5,000
Bromberg	2,500	Osaka	4,000
Westergein	5,000	Contemplated in India, South	
Knapsack	5,000	Africa and Canada	12,000

The manufacture involves problems in chemistry and in mechanical engineering. It requires the liquefaction of air and the separation of the oxygen and nitrogen respectively therefrom. The furnaces in which the calcium carbide combines with the nitrogen are of considerable electrical interest (although not a very high temperature is required), and the arrangement both for grinding the material to a fine powder and for the handling thereof from stage to stage in the process of manufacture are of mechanical interest, because a high degree of economy has been attained as in the case of the carbide factory already described.

Apart from the important work of obtaining the nitrogen from the air, the chief desideratum in the process is to ensure that no air comes in contact within the carbide during its 30 to 40 hours' treatment in the furnace, as the oxygen in the air would increase the proportion of carbonate of lime at the expense of the cyanamide and reduce the percentage of nitrogen.

One element conducive to economy is that the process is endothermic, the absorption of nitrogen by the carbide generating a large proportion of the heat necessary to effect the combination, so that the 196 electric furnaces in use, each producing 1 ton of nitrolim per week and operated at 60 volts to 75 volts, requires comparatively little electrical energy to maintain the temperature at from 800° C. to 1000° C. (1470° Fahr. to 1830° Fahr.). Care has also to be exercised in order to ensure the uniform distribution of the temperature throughout the furnaces.

The preparation of the calcium carbide for the absorption of the nitrogen in the electric furnaces includes the grinding of the carbide to a powder before it is charged into the furnaces.

maschinen Gesellschaft, Munich, Germany. The process is the invention of Professor Linde. It is based on the fact that at atmospheric pressure, nitrogen boils at — 196° C.; liquid air boiling at — 194° C., and liquid oxygen at — 183° C. By using the well-known rectification process followed in the manufacture of alcohol, the nitrogen can be completely separated from the oxygen.

The Linde company guarantees that the nitrogen does not contain more thon 0.4 per cent oxygen, a percentage which has neither an unfavorable influence on the chemical reaction nor leads to the burning of the electrodes. The plant has been working for several months, and the guaranteed maximum has never been exceeded. It was cut down by the Linde company for a production of 375 cu. m (about 13,000 cu. ft.) per hour and is run by a 200-hp electric motor. All parts are in duplicate in order to prevent any long interruptions in the working, the second half of the plant acting as a stand-by.

The diagram, Fig. 7, shows how the separation of oxygen and
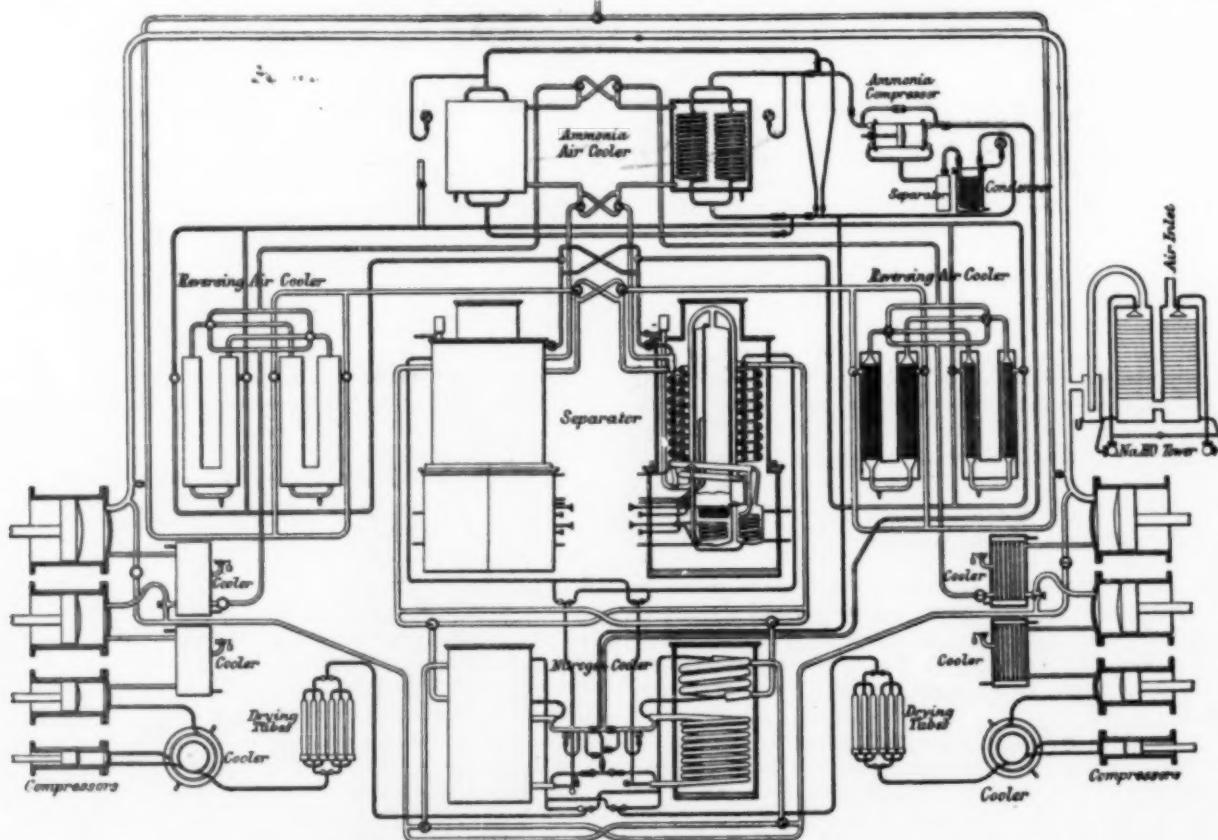
FIG. 7.—LINDE PLANT FOR SEPARATING NITROGEN AND OXYGEN FROM AIR.

The carbide is first conveyed by an aerial ropeway from the cooling house at the carbide works to the building where the grinding machine is erected. It is then passed into hoppers, to which the retorts are brought by an overhead crane to be filled under a shoot, and then conveyed and placed in the furnaces.

The nitrogen is applied in the electric retorts, and at the end of 30 to 40 hours these are taken out of the furnaces and conveyed to a cooling platform where the cyanamide is removed. It has then the form of cakes, of great hardness, not unlike coke. Subsequently, this cyanamide, or nitrolime, is ground to a fine powder and is subsequently stored in silos having a capacity of from 6000 to 8000 tons. It is taken thence by automatic machinery, packed into double bags having an inner lining of paper to exclude any moisture, which would be detrimental to the nitrolime.

Liquid Air Plant for Production of Nitrogen.—Attention may now be directed to the plant for obtaining the nitrogen from the air. This has been constructed by the Linde Eis-

nitrogen from the air takes place, and will better explain the process than would sections through the various apparatus. The right half of the diagram represents the part of the plant in actual working; the left half shows the part held as a stand-by. We shall deal only with the former part. Fig. 8 is a perspective view of the Linde house.

The air to be treated is drawn from the atmosphere by the largest of the four cylinders of the compressors, and through two towers, through which a soda liquor is made to trickle, the object of this being to free the air as much as possible from carbonic acid.

The air is compressed to approximately 4 atmospheres (57 lb. per square inch). It is then cooled, first, in a water-tower down to the temperature of the cooling water, and, further, by being passed in pipes through a reversing air cooler. Around these pipes flow cold oxygen or nitrogen from other portions of the apparatus. The water condensed is drained off at the bottom.

In the rising leg of the apparatus ice is liable to form as the temperature is below freezing point. It is got rid of by periodically reversing the direction of the flow by the valves indicated.

The air next passes to an ammonia-cooler, where its temperature is further reduced to about — 20° C. or — 25° C. In this almost the whole of the remanent moisture is abstracted.

On leaving this almost absolutely pure and dry the air passes next to the separator or still, which it enters through a counter-current interchanger consisting of the usual system of concentric pipes. Flowing itself through the inner of these pipes, it is cooled by an oppositely flowing current of nitrogen or oxygen evaporating from the liquid state.

The incoming air thus passes from the interchanger at a very low temperature and being led next to a coil immersed in a tank of liquid oxygen liquefies there, since it is at a pressure of 4 atmospheres.

From this coil it expands through a throttle valve, with the result that a large proportion of it is obtained in the liquid state, and at about atmospheric pressure. The liquid thus produced is led to a point near the top of a rectifying column filled with glass marbles, over which it trickles to the bottom.

On its way down it meets with an ascending current of gas evaporating from liquid below. This gas is rich in oxygen, and this oxygen having a higher temperature of liquefaction than the liquid air it meets in the rectifier, is condensed by an equivalent proportion of nitrogen being distilled off from the descending liquid.

The latter therefore enters the tank at the bottom enriched in oxygen, while the gases passing off above are nearly pure nitrogen. To remove the remaining traces of oxygen the rectifying

FIG. 8.—LINDE PLANT FOR OXYGEN AND NITROGEN FROM AIR.

column is extended at the top above the point at which the liquid air is introduced.

The gases ascending through this extension meet a downward flow of pure liquid nitrogen which robs them completely of oxygen so that finally pure gaseous nitrogen alone escapes from the top of the column. Of the supply thus obtained the bulk is drawn through the interchanger to the electric furnaces, but a proportion goes to form the supply of pure liquid nitrogen needed in the upper part of the rectifying column.

To this end it is led into the second cylinder of the compressor, and thence, through intermediate coolers, to the other cylinders, from the last of which it is delivered at a pressure of 120 atmospheres.

After cooling and cleaning, the compressed gas is next passed through a coil in a tank of liquid oxygen derived from the separator. Here it condenses to the liquid state, and is finally passed through a throttle valve to the top of the rectifying column. By expansion through the valve the supply of liquid nitrogen at low pressure needed for rectification is obtained. The oxygen separated from the air is evaporated in a special receiver by a portion of compressed air, and is led by a special pipe to the counter-current spiral to cool the compressed air.

The evaporation of the ammonia in the coolers is governed by an ammonia compressor, which draws the ammonia vapors from the coolers and compresses them in a condenser in which they are precipitated for delivery afresh in a liquid state into the coolers.

As it is not possible to free the air in a large measure from moisture and carbonic acid before its entrance into the separator, the separator is gradually choked up. The working period lasts six to ten days. In order that no interruption should take place, the second half of the plant is started working a few hours before the first half is stopped, and when this is done the second half is already yielding nitrogen.

Three Years' Practice of the Townsend Cell.*

By L. H. BAEKELAND, Sc. D.

In 1907 I have described the Townsend cell and its practical operation. (ELETROCHEMICAL AND METALLURGICAL INDUSTRY, June, 1907; *Jour. Soc'y Chem. Ind.*, Vol. 26, No. 13). I am able now to make a further report on this subject from data gathered during almost three years and a half of continuous operation of the Niagara plant, using about 1000 kw, and which is now rapidly being increased to a quadruple capacity.

The cell units as used originally were designed for 2000 amp, but it was found afterward that by a slight alteration these same cells could be operated more advantageously at 2500 amp; since about a year, 76 cells have been thus run at this increased load. On the strength of our experience, all the new cells which are being installed will run at a minimum load of 5000 amp; they are designed so, that in case of necessity, they can be forced up to 6000 amp, and still run at good efficiency.

The first full-sized Townsend cells, as designed by Townsend and Sperry, which we had under observation in 1904, were run either alone or in series of three and under those conditions showed astonishingly high amphour and energy efficiencies. Under such conditions the amp-hour efficiencies were close to 100 per cent. But it makes a considerable difference whether an electrolytic cell be run alone, nursed by experts, or whether it be operated in large series and left in the hands of unskilled workmen.

In a series of, say, over 70 of such cells, it frequently happens that one single defective cell depresses considerably the average efficiency of the whole group; irregularities in the circulating electrolyte may often do considerable damage in the whole system and escape detection while doing much mischief. Furthermore, remedies cannot always be applied immediately, because it is often more expensive to stop a whole plant, which

*A paper read before the International Congress of Applied Chemistry in London.

is intended to run without the slightest interruption. These and other practical considerations have frequently been overlooked by scientists or inventors who had no opportunity of being brought face to face with purely commercial considerations.

Practice and experience alone can teach us the relative importance of all these matters, and the cold-blooded bookkeepers' accounts very often upset the most elaborate estimates of the chemist or the engineer.

The latter naturally have a tendency to put great stress on the value of high efficiencies, and yet this factor, considered alone, is often very misleading. For instance, we soon found that it was much cheaper to sacrifice some power, and accept somewhat higher voltages, as to run the cells at a higher output and turn out more goods with the same size of plant and the same cost for the operating staff.

At one time it was thought advisable to run the Townsend cell at current densities not exceeding, say 100 amp per square foot of anode surface, which enabled us to operate at very low voltage and to show rejoicingly high energy efficiencies, and which kept the graphite anodes almost intact of corrosion; but later on the bookkeeping accounts convinced us that it was better business policy to run at about 1 amp per square inch, sacrifice some power and some graphite and yet show better financial results in the end.

In fact, close observation of all the facts connected with cell operation has enabled A. H. Hooker to elaborate a system of curves whereby we can now design Townsend cells of various sizes and output which can be operated at any desirable voltage and of which we can tell beforehand not only the value of output, amp-hour and energy efficiencies, but the cost of maintenance and even the number of days which will elapse between two successive cleanings of the diaphragm.

With all these factors at hand we have been able to decide which way of operating was cheapest in the end. For instance, we found that it was good practice to run the cells so as to clean the diaphragm once in about 30 days, although a slight

VOLT-AMPERE CURVES.
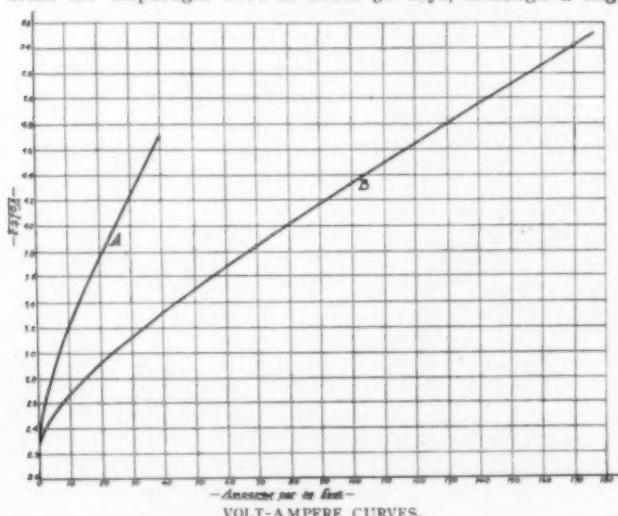
change in the way of operating enables us to considerably lengthen this period, but it was preferable to design the cell so as to make opening, examination and cleaning so easy and inexpensive that any cell which has to be thus treated remains out of active service only for a few minutes. Likewise, after we had decided that it was more advantageous to run at such high loads that the graphite anodes begin to be attacked, the latter were designed of compound construction, so as to make renewals very simple and to limit the attack to the surface blades, so that the graphite can be used over and over again until it is entirely consumed. So successfully has this been accomplished that a conspicuous part of many electrolytic plants, the cemetery of old anode parts, has entirely been done away with.

But if circumstances demand it, we shall have it within our power to change the operating of the cells so as to run at very low voltage and this at current densities which are still relatively large as compared to some other cells, and at the same time reduce the consumption of graphite to a very minimum. In places where power is very expensive, and skilled labor is cheap, it may prove advantageous to operate that way and construct the cells acordingly.

The accompanying curve B shows a record of the average voltage of a series of 76 cells, run at varying current densities, the latter being calculated per active surface of anodes. These voltages are decidedly higher than the initial voltages at which the cells are started.

The curve A shows a similar record for a well-known electrolytic cell, which I shall not name, and which has been in full commercial operation for a number of years.

It may be of interest to state that we found the use of aluminium conductors very advantageous, although at the time they were adopted considerable scepticism was expressed as to their value for a plant of this kind. The conductivity of aluminium is decidedly less than that of copper and, on account of this fact, bars of large section have to be used; notwithstanding this, the relation of price and specific gravity is such that there is a decided initial economy in the use of aluminium.

But the main advantage resides in the fact that someway or other aluminium has proved less liable to corrosion in an atmosphere where small amounts of chlorine are occasionally present. So little effect is there that even after years of continuous use the unvarnished or unpainted aluminium bars show a relatively bright surface. On the other hand, copper conductors under the same conditions become rapidly covered with a soft but thick crust of some basic chloride of copper which, on expanding, seems to favor further corrosion and disintegration.

Although the Townsend cell is commonly described as a diaphragm cell, I should point out that we may just as well consider it as a cell with a circulating electrolyte, somewhat on the order of the gravity cell, with that difference that here the cathode liquor is pressed through capillary channels and this insures rapid circulation in one sense and minimizes the possibility of diffusion.

By a very simple device, consisting of a glass tube which can be raised or lowered, the hydrostatic pressure in the anode compartment can be quickly adjusted so that the percolating liquid can be made to vary in flow and in strength. When we take into consideration the very large current densities at which the Townsend cell is run, it becomes a matter of course that the liquid should be pressed through the diaphragm at a rather abundant rate.

It has been found that the advantageous rate of percolation for 2500-amp cells is included in rather broad limits, say, from 15 liters to 30 liters per hour; the maximum rate of percolation giving the weakest caustic solution.

At one time it was though that in order to obtain advantageous amp-hour efficiencies it was necessary to make the perlation abundant enough so that the cathode liquid should not contain over 10 per cent of NaOH. Since then, experience has taught us that this is not strictly so. The 2,500-amp cells are run now at an average percolation of about 24 liters per hour, yet the caustic liquid contains an average of 150 grams of NaOH and about 200 grams of NaCl per liter of liquid.

But even this average corresponds to conditions which are not considered very favorable, and from what has been accomplished already we know that a cathode liquor of 20 per cent NaOH and an average amp-hour efficiency of 96 per cent is within possible reach, although thus far these results have not been obtained steadily for the full set of cells. We also know that the cathode liquor can be made as strong as 25 per cent NaOH, but this involves close watching and it is simpler to evaporate a somewhat weaker cathode liquor.

One of the remarkable conditions in the Townsend cell is

the almost entire absence of hypochlorites and chlorates in the anode liquor. This in itself is one of the symptoms of high efficiencies. The presence of these oxygen compounds in any electrolytic cell for the manufacture of caustic or chlorine indicates defective construction, or bad operation, or both. The formation of chlorates or hypochlorties is mainly due to recombination of the causticcation with the chlorine o fthe anode compartment.

It has been observed that whenever the Townsend cell begins to show low efficiencies, the anode liquor indicates relatively large amounts of chlorates and hypochlorites. For instance, if the average amp-hour efficiency falls to about 93 per cent, then the anode liquor shows as much as 0.6 gr. of the $NaClO_3$ and 0.1 of NaClO per liter. The presence of these undesirable compounds not only lowers general efficiencies, but hastens very considerably the graphite anode corrosion.

The caustic cathode liquor of the Townsend cell contains very little, if any, of these oxygen compounds, and this explains easily why, during the evaporation of these lyes, so little trouble is experienced, as far as concerns the corrosion of the metallic vessels, in which the evaporation occurs.

Our method of treating the cathode liquor can be described summarily as follows: The liquor, containing at least 14 per cent of NaOH, flows in a set of three vacuum pans run in multiple effect. When leaving the last pan most of the sodium chloride has already been eliminated and the clear, thick liquor now contains about 50 per cent NaOH; 0.8 per cent Na_2CO_3 and 2 per cent NaCl. This liquor is now further concentrated in open finishing kettles.

The finished product, as sold in drums, titres from 76 per cent to $77\frac{1}{2}$ per cent New York and Liverpool test. It is of excellent white appearance and contains rather less than 2 per cent carbonate, and a small amount of NaCl, which it does not pay to eliminate further.

It is a known fact that whenever caustic lyes contain impurities, more especially when they contain hypochlorites or chlorates, a rapid corrosion of the heating tubes in the vacuum pans follows, as well as a rapid destruction of the cast-iron finishing kettle. This naturally involves, first of all, bothersome and expensive renewals of the tubes in vacuum pans, and the expense for this item has been brought down to an occasional small repair.

Furthermore, it has been found that our finishing kettles last an unusually long time. This factor of renewals of finishing kettles is usually a serious item of expense. After a certain number of tons of caustic have been finished in one single kettle, the latter gets in such a bad condition that it has to be sent back to the foundry and be sold as old iron. Some of our pots have thus far finished over 3000 tons, and are still in very good condition, and promise a much longer record. In one or two instances where pots had to be discarded, the damage was merely due to very careless firing, and not to corrosion.

In direct relation with all this stands the other fact, that the finishing of Townsend caustic produces only a relatively small amount of so-called "bottoms." These "bottoms" are a variety of impure caustic, which gradually accumulates in the kettles, and which contains all the impurities, mainly due to the effect of corrosion on the metallic vessels in which the evaporation is carried on. Such "bottoms" have to be sold at a loss, and oftentimes are a decided "drug on the market." Up till now, the rates of the quantity of "bottoms" to that of first-quality caustic soda which has been produced by the Niagara plant has averaged only one ton in 700 tons of finished caustic, and even this includes the results of the starting period, when the plant was not in proper running condition, and when our operating staff was considerably less skilled than now. But this much can be said as to the wear of finishing kettles and pans, that until now this item of expense averages less than 20 cts. per every ton of finished caustic,

and there is every probability that in the future this cost will be considerably reduced.

The Preparation of Aluminium in the Laboratory.

BY S. A. TUCKER.

Aluminium may be prepared in the laboratory on a small scale without difficulty and give an excellent illustration of the Hall process which is of value to the student of applied electrochemistry.

The method which I have found successful is to use a furnace as illustrated. This consists of a crucible A turned from a 5-in. diameter graphite rod resting on the graphite base B, which forms the negative pole of the circuit.

An adjustable vertical graphite electrode C, $1\frac{1}{4}$ in. diameter, is connected to the other pole through a variable resistance. The power circuit should be 110 volts, having a capacity of about 300 amp, and provided with a circuit-breaker and ammeter.

In order to conserve the heat as much as possible the crucible A is surrounded with any good heat-insulating material,
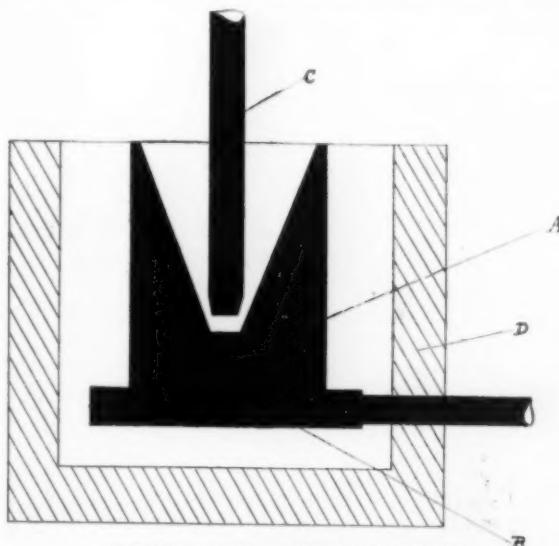
APPARATUS FOR ALUMINIUM PROCESS.

such as infusorial earth, sand or lime, which is retained by the brickwork D. The crucible can be made conical as shown so that a wide opening is maintained and but little charge used, or a cylindrical container can be used equally well.

The voltage is measured by inserting a voltmeter reading to 150 volts across the poles.

The process is started by lowering the vertical electrode until an arc is formed on the bottom of the crucible. As soon as the crucible is warmed somewhat, cryolite in lumps of about $\frac{1}{2}$ in. diameter is added, allowing time for them to melt, adding in quantity sufficient to fill the crucible two-thirds full.

When perfectly fluid the volts will be about 80 and the current 30 amp, the vertical electrode being placed as near the bottom of the crucible as posible without arcing.

If the weight of the cryolite added has been noted, 15 per cent of purified alumina can then be added in small portions, and as soon as an appreciable quantity is taken into solution the volts will fall to from 10 to 12, the current rising to 225 amp. Bubbles of carbon monoxide will ascend from the anode by the inter-action of the oxygen and the graphite, showing that the process is going on correctly.

There are two causes which will interfere with the progress of the experiment in this way: first the anode is corroded quite rapidly, increasing the distance between anode and cathode, and, second, the decomposition of the alumina raises the resistance of the bath. Either cause tends to make the conditions revert to high voltage and low current.

When this does take place the electrode is lowered, and if this does not bring about the required change, a little more alumina is added to the bath, the aim being to maintain by these means a low voltage, high amperage, and an evolution of gas bubbles from the anode. Sometimes when the voltage suddenly rises a tap on the electrode holder of the vertical electrode will set things going again in the proper manner, apparently because the sudden shock dislodges a gas envelope around the anode.

The process should continue for an hour or an hour and a half in order to obtain an appreciable quantity of the metal, and is discontinued by withdrawing the vertical electrode and lifting the crucible with a pair of tongs while the contents is still molten and pouring into an iron mold. On cooling the aluminium is usually found in one button weighing from 20 to 30 grames.

It sometimes happens that too much alumina has been added which tends to make the charge very hot, accompanied by sputtering. This is corrected by the addition of more cryolite and allowing the process to proceed in the manner indicated.

A crust will probably form on the surface of the bath, but will do no harm provided that it is not allowed to congeal around the anode. This can easily be prevented by breaking into the crust with an iron rod.

I give the details of this experiment because I have been informed that others have experienced difficulty in carrying it out successfully.

ELECTROCHEMICAL LABORATORY, COLUMBIA UNIVERSITY.

An Apparent Increase in Electrolytic Conductivity Along Lines of Magnetic Flux.

By C. J. REED.

An accident to a submerged magnetic separator, which occurred about a year ago, caused a peculiar corrosion in the copper tube surrounding the magnet. The peculiar locus of corrosive action showed that the line of the least resistance to the electrolytic current is along the lines of most intense magnetic flux and that, therefore, there is an increased electrolytic conductivity along those lines. As no explanation has been offered by those to whom the phenomenon has been described, the writer thought that by giving the facts publicity, through the columns of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, some other explanation might be found and that the matter would be of sufficient interest to induce further investigation.

The magnet in question consisted of a steel core, 37 in. long and 2.5 in. in diameter, having 10 steel disks, 6 in. in diameter and 0.75 in. thick, equally spaced along its length, acting as circular magnetic pole-pieces of alternate N and S polarity. The spaces between the disks contained in the energizing coils and the magnet was encased in a close-fitting copper tube about 3/64 in. thick, which was intended to protect the magnet from moisture, as the apparatus is continually submerged in water (paper pulp). The magnet operates on a 110-volt circuit

FIG. 1.—CORROSION OF COPPER TUBE.

The copper tube, after removal, was photographed and is shown in Fig. 1. The irregular vertical slit extending from end to end was made with a knife to facilitate the removal of the tube from the magnet. Fig. 2 shows the upper end and Fig. 3 the lower end of the tube on a larger scale. The circular lines a at the top and b at the bottom of the tube are lines of corro-

FIG. 2.—UPPER END.   FIG. 3.—LOWER END.

sion where the copper had been dissolved out, and correspond to the edges of the pole-pieces. They were, therefore, also the loci of the most intense magnetic flux. The lines c, corresponding to the central pole-pieces, showed no corrosion, the marks being evidently caused by the normal action of the separator in collecting particles of iron from the surrounding mass of pulp, leaving a mark in the pulpy sediment covering the general surface.

The presence of particles of iron on the lines a and b could not account for the corrosion at those places on any theory of local action, as the iron is electro-positive to copper. If the tube had been a zinc tube, such an explanation would have had elements of probability, but with a copper tube it could not hold.

The accident which produced the above-mentioned result was caused by a stream of paper pulp (95 per cent water) flowing continually against the lower part of the tube d and finally wearing away the tube and allowing the water to come in contact with the lower coils, grounding the magnet. The windings were so connected that the grounding caused current to flow from the ends of the tube into the water and from the water into the tube again at the center. This produced corrosion at the ends only. The apparatus was in this condition several weeks before the attendant located the trouble which necessitated the removal of the tube.

The peculiarity of the action is that the electrolytic corrosion of the copper was confined to the regions of most intense magnetic flux, affording grounds for the inference that the electrolytic conductivity along those lines was so enormously increased as to carry practically the total current.

PHILADELPHIA, PA.

Dr. **Edward G. Acheson's** portrait greets the reader from the front cover of the July issue of *The Press Scrap Book*, and the leading article of this issue is a fascinating biographical sketch of Dr. Acheson as "America's most successful discoverer in practical chemistry." The same issue contains biographies and portraits of Mr. Bion J. Arnold, the distinguished electrical engineer, of Chicago and New York; of United States Senator Simon Guggenheim, of Colorado; of Mr. Herman A. Metz, the chemical manufacturer and present comptroller of New York city ("a public official in whom the people have confidence"); of Judge Alton B. Parker, of Senator Elihu Root, and others. The whole issue, with its diversified contents, is certainly of great interest, and the mechanical make-up and the portraits are very attractive.

An Outline of a New Practical Method for the Calculation of Atomic Weights.

By Dr. Gustavus D. Hinrichs.

Every quantitative chemical analysis consists of two entirely distinct kinds of work; namely, the chemical or laboratory work proper and the reduction or calculation of the same by means of the so-called chemical constants, the atomic weights of the chemical elements. The final result of such an analysis depends equally upon both these divisions of work. If the values of the atomic weights used in the second act are not true to nature, the final numerical results of the analysis will be as surely in error as if the chemical work had been faulty while the atomic weights used were true.

For nearly 20 years I have shown in the *Comptes Rendus* of the Academy of Sciences of Paris and in the *Moniteur Scientifique*, as well as in my special books[1] of 1894 and 1901 that the so-called *Official Atomic Weights* of the American Chemical Society are not true to nature and that therefore the laboratory work done throughout the United States has been persistently falsified these many years.

This includes necessarily even the most elaborate atomic weight determination of Prof. Th. W. Richards and his school of Harvard (and now also of Berlin), published by the Carnegie Institution of Washington and in the *Journal* of the American Chemical Society, including especially the most noted of these publications in the number of said *Journal* for January, 1909, which I have just analyzed in the *Moniteur Scientifique* at Paris, having repeatedly found it impossble to get any hearing in American journals.

Thanks to the editor of the Electrochemical and Metallurgical Industry I am now permitted to address the American chemists on this most important topic and shall, in the briefest manner possible, demonstrate that the above statement in regard to the atomic weights is strictly true. Since of late it has become somewhat habitual to present the results of atomic weight determination in this country[2] in the remarkable form of a three-fold double *IF*, it will be necessary for us to go down to rock-bottom to reach solid ground for the new structure to rest upon.

I.—*The Standard of Matter* (matière étalon) adopted by us is the Diamond-Carbon; for reasons see *Comptes Rendus*, 117, 1075; 1893.

II.—*The Unit* is exactly 1/12 hereof, or $C = 12$ exactly. See Hinrichs' True Atomic Weights, pp. 20-24; Hinrichs' Absolute Atomic Weights, pp. 101-105; *Mon. Scient.*, 1909, pp. 740-742; giving $O = 16$ exactly.

III.—*The actual atomic weight X* of any element, as a matter of fact, differs by only a small fraction ϵ (*the departure*, or l'écart) from a round number (a) which we call *the absolute atomic weight* and which commonly is a whole number, sometimes ending with one-half, and rarely with one-fourth or one-eighth. Hence the true atomic weight will be represented by $X = a + \epsilon$.

IV.—*For Hydrogen* the absolute part is one and the departure is real and equal to 1/16 of 1/8, or 0.008713, which I have shown to be the weight of one atom of the primitive matter, pantogen; $H = 1 + \pi$. See *Comptes Rendus*, 147, 797; 1908.

V.—*The values of the absolute atomic weights* of the 30 elements considered in the table of values appended are, in alphabetical order:

Ag, 108; As, 75; Bi, 208; Bo, 11; Br, 80; C, 12; Cd, 112½; Co, 59, Cu, 63½; Dy, 162½; Fe, 56 or Fe′, 56 − ⅛; H, 1 + π; He, 4; Hg, 200; In, 115; Io, 127; Ka, 39⅙; Mg, 24 or Mg′, 24¼; N, 14; Na, 23; O, 16; Pb, 207 or Pb′, 207¼; Pt, 195; Ra, 226½; S, 32; Tb, 159; Te, 127½; Tl, 204; Wo, 184.

VI.—The final outcome of this research has been that the

values of the departure ϵ are smallest for the most accurate chemical determinations made and that they for each element show opposite signs if several determinations have been made after independent chemical methods. See the values of the departures found in the columns headed ϵ of our table giving these departures in thousandths of the unit.

Therefore, these departures are simply residual errors of the experimental work, so that the above absolute values are the true atomic weights of the chemical elements.

VII.—Since the actually obtained departures ϵ, as a matter of fact, are quite small fractions of the unit of atomic weights, all calculations with the actual atomic weights $X = a + \epsilon$ can be carried out by proportional parts and all geometrical constructions required can be effected with straight lines.

VIII.—In this way, every given chemical reaction is specifically characterized by numerical values readily calculated and which we have named *Variations;* we represent them by the letter delta Δ.

IX.—If the value of the variation for an element in a given reaction is large, the reaction is *sharp* for that element considered and the resulting atomic weight will be a value of high precision.

If, however, the variation for the element considered be small, that reaction is called *dull* and it will not be possible to obtain a value of precision for the atomic weight of that element from the chemical reaction considered.

It will be at once apparent that *this criterion* is of the greatest practical value in the work of atomic weight determinations. See, for example, Lenher's attempt to determine the atomic weight of Tellurium: *Comptes Rendus*, 148, 484; 1909.

X.—The chemical reaction used for atomic weight determinations requires *two accurately weighable compounds, P* and *Q*, of which one is directly convertable into the other, best without change of the containing vessel.

XI.—For any one determination or experiment, the actual weights *p* and *q* of these compounds are taken and their ratio is calculated to five decimal places, this being the limit of the best chemical work done at present. We call this value the analytical ratio, $\rho = \dfrac{p}{q}$.

XII.—A certain number *n* of determinations is made of which the mean is taken. *The range r* is the difference between the highest and the lowest ratio found (in units of the fifth decimal). The range gives a good measure of the concordance attained in the determinations made. There is no need of calculating the probable error of the mean; we have repeatedly shown up the abuse that has been made of this chemically little important number.

XIII.—*The three numbers, ρ, r* and *n*, fully express the results of the laboratory work done for the atomic weight determination.

XIV.—Inserting the absolute atomic weights in the formulæ of the two pure chemical compounds used, *P* and *Q*, we can calculate *the atomic ratio R* of the chemical reaction used. For example, the combustion of the diamond (No. I of our table) gives

$$R = \frac{P}{Q} = \frac{C}{CO_2} = \frac{12}{44} = 0.27273.$$

XV.—*The Variation* Δ for any one element in such a chemical reaction is the increase of R for an increase of 0.1 in the atomic weight of that element.[1] It is understood that all calculations are made to five decimal places, and that the resulting variation is expressed in units of that place, not as a decimal.

For example, in the above case of the combustion of the diamond (No. I of the table) we find

$$\Delta C = 165, \quad \Delta O = -124.$$

XVI.—In the reduction of $Pb\,O$ to Pb by Berzelius we find $R = 0.92825$ and $\Delta Pb = 3$, $\Delta O = -40$; see No. 8 in our table. This reaction is, therefore, very dull for Pb; hence the result obtained is subject to doubt.

[1]The True Atomic Weights, St. Louis, 1894. XVI and 256 pp., 8vo, 7 plates. The Absolute Atomic Weights, St. Louis, 1901, XVI and 304 pp.; 8vo, 3 plates.
[2]*Carnegie Publication*, No. 69, p. 65, p. 87-88, 1907; also in late issues of *Journal Am. Chem. Society.*

[1]Absolute At. Wghts., 1901, pp. 64-65.

Recently Baxter used reaction No. 45 of our table which requires the absolute value 207¼. The variation for Pb is 10 times as great as the one for the reaction used by Berzelius; but there are other matters involved so that it will require further chemical research to definitely settle the atomic weight of lead.

XVII.—*The analytical excess* $e = \rho - R$, is expressed in units of the fifth decimal. The mean value, in the case of lead just mentioned, is 2.1 for No. 8 and 25 for No. 45. In this regard, No. 45 is less reliable than No. 8.

XVIII.—Our *Equation of Condition* connecting the departures ϵ of the atomic weights, the analytical excess e and the variations Δ of any chemical reaction is

$$10\,\Sigma\,\epsilon\,\Delta = e + k$$

where k represents the constant error of the chemical work.

XIX.—This most important relation was first published in the *Comptes Rendus*, T. 145, p. 715; 1907. In this edition the factor was misplaced and k was included in e.

It is understood that the sign Σ comprises as many terms as there are elements involved in the chemical reaction; hence, there are at least two such terms. Consequently, this equation is always diophantic with at least two unknown; it can therefore be solved only by repeated trials—that is, by gradual approximation.

XX.—As a first approximation, we may neglect k and divide the analytical excess equally between the m elements present. By this *ex-aequo solution* we obtain as first approximation the values of the departures by

$$\epsilon = \frac{e'}{10\,\Delta} \text{ where } e' = \frac{e}{m}.$$

Compare *Comptes Rendus*, T. 145, p. 60; 1907.

Example.—Berzelius' determination for Pb (No. 8) gives $e = 2.1$; hence $e' = 1.05$ and since $\Delta Pb = 3$, the departure for Pb is $\epsilon = 0.035$; since ΔO is -40, the departure for O is $\epsilon = -0.003$.

XXI.—If the laboratory work does not yield satisfactory results, it must be repeated with greater care and even other chemical reactions should be tried, as already indicated in the case of Pb above. If no satisfactory results have been reached, the absolute atomic weight assumed may be in error.

Note.—Our graphical method, of which a preliminary publication has been made in 1907, will not be required in practice until the laboratory work has reached a higher state of precision. See *Comptes Rendus*, 145, 715-718; *Moniteur Scientifique*, 1907, 733-750, and 1908, 155-172.

XXII.—In the above indicated manner, the outstanding departures ϵ will rapidly diminish, after a few trials, since every step taken is in the open and on solid ground.

XXIII.—The adjoined table gives the results obtained from 60 chemical reactions, containing 30 different elements and giving 182 individual determinations of atomic weights—that is, an average of three per chemical reaction.

XXIV.—There are found in this (the first table of its kind) 35 independent determinations of the atomic weight of Ag and 34 for O—that is, 69 determinations for these two elements, Ag and O.

Again there are 27 determinations for chlorine and 11 for bromine—that is, 38 determinations for these two chloroids.

For Ka we find 6 and for Na 5 determinations; hence 11 determinations for these two kaloids.

These few data express in a striking manner both the novelty and the power of the new method here given.

XXV.—An examination of the details of this great table will prove exceedingly interesting and instructive. We shall return to this work in a near future, after having added sufficiently to the table here presented.[1]

In the meanwhile we trust that the reader will succeed without further assistance in the study of this table, always remem-

bering that the departures are given in thousandths of the unit and can be properly estimated only in connection with the character of the reaction used, expressed in the variation. See IX.

The famous Reactions, 6, 35 and 36.—Prof. Th. W. Richards has practiced these three reactions in his famous work done at Harvard University and Berlin University. The Carnegie Institution of Washington has assisted him; the Warren Research Fund in Harvard and the men and means of the First Institute of Chemistry of the University of Berlin were at his service.

The results of this research were published in the *Carnegie Publication* No. 69, of 1907, and in the January number of the *Journal* of the American Chemical Society for 1909. This last publication gives the details for Reaction No. 35 of our table, and the general results for all three, including as particularly important the mode of calculation actually used by Professor Richards (p. 19) so as to leave no possibility for doubt about this all important matter.

Professor Richards in his publications informs his readers at nearly every operation about the perfection of his work; for example, on page 20 of the journal cited, he declares: "These analyses were superior to any other that have ever been made." Besides he does not omit to declare (l. c., p. 7) "most of the previous work is unsatisfactory" and notably Stas' work and materials were regretfully inferior. In this connection I may admit that I have never seen any other chemist than Richards omit 4 of every 10 of his determinations without saying much about it; by selecting 6 out of 10 made, the show may be considerably improved even at a fine stock show. See l. c., p. 18.

However, we have given the results of the laboratory work of Professor Richards exactly as he reports it (see our table, Nos. 6, 35 and 36). We find for the atomic weight of silver the following departures (in thousandths of a unit) from the absolute value of 108:

No. 6, 5 high. No. 35, 17 low. No. 36, 45 low.

The mean of these three is 19 low, giving Ag 107.981. But the reaction No. 36 has been shown to be unfit for accurate atomic weight determinations on account of the large systematic errors the results present (see *Moniteur Scientifique*, 1908, p. 454-457; 1909, p. ii-16).

This leaves only Nos. 6 and 35, which give the mean of 6 low making Ag 107.994. There can be no possible question about this being the only result obtainable from the laboratory work as it is published by Richards himself in the periodicals mentioned.

XXVII.—In the January number of the *Journal* of the American Chemical Society (p. 20), Professor Richards gives the entirely different value Ag 107.881 and the number 107.88 has already made its appearance in chemical literature. Its departure from the true value which is confirmed by the laboratory work of Professor Richards himself as just shown (XXVI) is 0.12 on 108, which is 1 in 900, or decidedly more than one-tenth of one per cent, an amount which is very great in this branch of chemistry; indeed, such a difference would make quite an error in any quantitative analysis.

In a paper of which I have read the proof and which is to appear in the June number[2] of the *Moniteur Scientifique* at Paris, I have shown how Professor Richards, in his mode of elimination (given by himself, l. c., p. 19) considers three really quite different weights to be identical as soon as he designates them by one and the same algebraic symbol. Such mathematical dreams (even if indulged in while in a chemical laboratory, whether of the University of Harvard or of Berlin) will wipe out the best of real chemical work done in any chemical laboratory of the world, and no blindly admiring school can prevent such astounding errors to be shown up—outside of the United States and of Germany—say, in France.

XXVIII.—The history of chemistry does not furnish a par-

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[1] The ratio No. 11 should have the third decimal 9 instead of 0; it should read 0.79937.

[2] This number has just reached me and contains the article, pp. 383-388.

No	Reaction	R	Δ	Δ	Δ	Δ	e	r	n	ε	ε	ε	ε	#642
1	$C : CO_2$	0.27273	C 165	O -124			0.9	95	15	C o	O o			Dumas 1842
2	$TlNO_3 : Tl$	1.30392	Tl -15	O 148	N 49		-0.8	5	10	Tl 2	O o	N o		Crookes 1872
3	$2NaCl : NaB_2O_7$	0.57921	Na 41	O -200	Cl 99	Bo -115	9	68	5	Na 6	O -1	Cl 2	Bo -2	Ramsay 1893
4	$Cu : CuSO_4 5H_2O$	0.25451	Cu 30	O -92	S -10	H -102	1			Cu 1	O o	S -3	H o	Richards 1892
5	$Na_3AsO_3 : 4NaCl$	0.66102	As -38	O -131	Cl 113	Na 38	-4.3	60	7	As 3	O 1	Cl -1	Na -3	Smith E.F 1896
6	$AgCl : Ag$	1.32870	Ag -30		Cl 93		-3	8	10	Ag 5	·	Cl -2		Richards 1905
7	$Bi_2 : Bi_2O_3$	0.89655	Bi 5	O -58			0.2	18	16	Bi 2	O o			Gutbier 1904
8	$Pb : PbO$	0.92825	Pb 3	O -40			2.1	15	9	Pb 35	O 3			Berzelius 1830
9	$Hg : HgO$	0.92593	Hg 3	O -43			6.6	12	5	Hg 110	O -8			Erdm. Mchd 1844
10	$Fe_2 : Fe_2O_3$	0.70000	Fe 37	O -131			1.5	144	14	Fe 2	O -1			Svanberg 1844
11	$Te : TeO_2$	0.79037	Te 13	O -100			14	15	8	Te 54	O -7			Gutbier 1904
12	$N_2 : N_2O$	0.63637	N 165	O -144			13	50	5	N 4	O -5			Guye. Ph. 1904
13	$2Ag : MnBr_2$	1.00465	Mn -47		Br -93	Ag 93	-1	7	15	Mn 1		Br ½	Ag -½	Baxter 1906
14	$2Ag : CdBr_2$	0.79266	Cd -29		Br -58	Ag 73	-15.5	8	8	Cd 2		Br 9	Ag -7	Baxter 1906
15	$2Ag : CoCl_2$	1.66154	Co -128		Cl -255	Ag 154	-34	18	8	Co 9		Cl 4	Ag -7	Baxter 1906
16	$InCl_3 : 3AgCl$	0.51452	In 23		Cl 34	Ag -36	-10	36	6	In -15		Cl -10	Ag 9	Mathers 1907
17	$Pt : N_2H_8Cl_6 Pt$	0.43913	Pt 13	N -20	Cl -59	H -79	-3	91	12	Pt -6	N 4	Cl 1	H 1	Seubert 1881
18	$S^{alt} : hydr. S^{alt}$	0.80800	Tb 5	O -55	S 8	H -172	2	6	5	Tb 10	O -1	S 6	H o	Urbain 1906
19	$RaCl_2 : 2AgCl$	1.03659	Ra 35		Cl -3	Ag -73	-0.5	15	2	Ra -1		Cl 6	Ag o	Mme Curie 1907
20	H	1.00781	H	He		π		59		H o		He o	π o	Noyes 1907
21	$2KaCl : Ka_2TeBr$	0.21765	Ka 23	Te -3	Cl 29	Br -19	-5	4	16	Ka -5	Te 42	Cl -4	Br 7	Lenher 1909
22	$KaCl : KaClO_3$	0.60856	Ka 32	O -148	Cl 32		-7			Ka -6	O 2	Cl -6		Stas 1860
23	$AgCl : AgClO_3$	0.74935	Ag 13	O -117	Cl 13		-14.5			Ag -28	O 6	Cl -28		Stas 1860
24	$AgBr : AgBrO_3$	0.79661	Ag 9	O -101	Br 9		-11			Ag -31	O 5	Br -31		Stas 1860
25	$AgIo : AgIoO_3$	0.83039	Ag 6	O -88	Io 6		-13			Ag -54	O 8	Io -54		Stas 1860
26	$AgNO_3 : Ag$	1.57407	Ag -53	O 278	N 93		73			Ag -34	O 14	N 19		Richards 1907
27	$Dy_2O_3 : Dy_2(SO_4)_3 8H_2O$	0.49273	Dy 14	O -90	S -19	H -103	-14.9	62	12	Dy -27	O 4	S 20	H 4	Urbain 1907
28	$NaCl : Ag$	0.54167	Na 91		Cl 92	Ag -50	18	4	10	Na 7		Cl 7	Ag -12	Richards 1905
29	$NaCl : AgCl$	0.40767	Na 69		Cl 41	Ag -29	13	4	10	Na 5		Cl 8	Ag -11	Richards 1905
30	$KaCl : Ag$	0.69097	Ka 93		Cl 93	Ag -64	10	3	7	Ka 4		Cl 4	Ag -5	Richards 1907
31	$KaCl : AgCl$	0.52006	Ka 69		Cl 33	Ag -38	-8	2	5	Ka -4		Cl -8	Ag 7	Richards 1907
32	$KaBr : AgBr$	0.63364	Ka 53		Br 20	Ag -33	9	2	4	Ka 6		Br 15	Ag -9	" "
33	$KaBr : Ag$	1.10301	Ka 91		Br 92	Ag -102	18	7	11	Ka 7		Br 7	Ag -6	" "
34	$2AgCl : Ag_2SO_4$	0.91987	S -29	O -118	Cl 64	Ag 4	-54	7	10	S 41	O 11	Cl -23	Ag -338	" (Hensgen R.)
35	$NH_4Cl : AgCl$	0.37304	N 70	H 279	Cl 44	Ag -26	18	4	9	N 6	H 2	Cl 10	Ag -17	" 1909
36	$AgNO_{3.0026} : Ag$	1.57407	Ag -53	O 278	N 93		73			Ag -45	O 9	N 26		" 1907
37	$Wo : WoO_3$	0.79310	Wo 9	O -102			6		6	Wo 33	O -3			Smith E.F 1904
38	$WoO_3 : WoCl_6$	0.58438	Wo 11	O 76	Cl -88		45			Wo 137	O 19	Cl -17		" 1904
39	$Ag_3AsO_3 : 3AgCl$	1.07549	As 24	O 94	Cl -75	Ag -5	43	38	8	As 46	O 12	Cl -13	Ag -220	" 1901
40	$Ag_3AsO_4 : 3Ag$	1.42901	As 31	O 124		Ag -39	24	56	7	As 25	O 7		Ag -20	" 1901
41	$2Ag : Io_2O_5$	0.64671	Ag 60	O -97	Io -39		-48		18	Ag -27	O 16	Io 41		Baxter 1909
42	$3AgBr : Ag_3AsO_4$	1.21814	As -26	O -105	Br 65	Ag -14	-20	14	11	As 19	O 9	Br -8	Ag 36	" "
43	$3AgCl : Ag_3AsO_4$	0.92981	As -20	O -81	Cl 64	Ag 4	-20	5	15	As 25	O 6	Cl -8	Ag -125	" "
44	$Pb Cl_2 : 2Ag$	1.28819	Pb 47		Cl 93	Ag -119	29	13	9	Pb 21		Cl 10	Ag -8	" 1908
45	$PbCl_2 : 2AgCl$	0.96951	Pb 35		Cl 2	Ag -67	25	33	6	Pb 24		Cl 9	Ag -7	" "
46	$AgBr : Ag$	1.74074	Ag -68		Br 93		5	14	18	Ag -4		Br 3		" 1906
47	$AgBr : AgCl$	1.31010	Ag -21	Cl -91	Br 70		7.5	6	13	Ag -12	Cl -3	Br 4		" "
48	$2AgBr : MnBr_2$	1.74884	Mn -81		Br -70	Ag 93	5	25	16	Mn -2		Br -1	Ag 2	" "
49	$2Ag : MnCl_2$	1.71429	Mn -136		Cl -272	Ag 158	18	9	7	Mn -4		Cl -2	Ag 4	" "
50	$2AgCl : MnCl_2$	2.27778	Mn -181		Cl -282	Ag 158	20	23	7	Mn -4		Cl -2	Ag 4	" "
51	$2AgCl : Ag_2CrO_4$	0.86446	Cr -26	O -104	Cl 60	Ag 8	-37	9	3	Cr 35	O 9	Cl -15	Ag -115	Baxter 1909
52	$2AgBr : Ag_2CrO_4$	1.13253	Cr -34	O 124	Br 60	Ag -8	-46	17	11	Cr 34	O -9	Br -19	Ag 144	" "
53	$2AgBr : Ag_2Cr_2O_7$	0.87037	Cr -40	O -141	Br 46	Ag 6	-51	9	9	Cr 32	O 9	Br -27	Ag -213	" "
54	$MgCl_2 : 2Ag$	0.44097	Mg 24		Cl 12	Ag -28	34			Mg 21		Cl 12	Ag -28	Richards 1896
55	$Fe_2 : Fe_2O_3$	0.69953	Fe 37	O -131			3	8	5	Fe 4	O -1			" 1900
56	$Hg : HgS$	0.86207	Hg 7	S -37			6		4	Hg 43	S -8			Erdm. Mchd 1844
57	$Hg : HgCl_2$	0.73801	Hg 9		Cl -55		5.6		3	Hg -33		Cl 5		Svanberg 1848
58	$Hg : HgCl_2$	0.73801	Hg 9		Cl -55		-10		2	Hg -56		Cl 9		Turner 1833
59	$MgO : MgOCO_2$	0.47619	MgO 119	CO₂ -6			-11			MgO -5	CO₂ 91			Mchd. Schre 1850
60	$Na_2Bo_2O_7 : 2AgCl$	0.70383	Bo 139	O 244	Na 70	Ag -79	163	121	5	Bo 24	O 14	Na 47	Ag -67	Ramsay 1893

allel to this stupendous error, or rather system of errors, which has for years been forced upon the unsuspecting members of the American Chemical Society in the Annual Reports on the Atomic Weights. The sixteenth has appeared in the March number, 1909.

I do not like to express my own opinion on this annual gamble in atomic weights; I therefor quote the closing part of a most striking and true editorial which, while written without any knowledge of the case in hand, surely lays bare the modus operandi thereof:

"It is all very well to speak of the tendency of the times to form commercial combinations and trusts for manufacturing on a large scale. But science, pure and applied, is promoted not in such a way. What counts here is individuality, the man as man. Great advances are made by opposing individualities. For the promotion of science and engineering, even in a limited field like chemistry only, nothing could be worse than the combination of the various scientific and engineering societies into one unit, with one publication committee and an editor in charge who as a practical dictator would determine what is suitable for publication and what not. It is unnecessary to add another word."

Personally I feel sure to say that it is unnecessary to add where this editorial was first published.

XXIX.—The United States Pharmacopœial Commission accepted these false atomic weights as standards for the eighth revision now in force in this country.

My endeavor to prevent this was vox elamantis in deserto. See, for example, my articles in *The National Druggist*, St. Louis, from November, 1900, to March, 1901.

XXX.—Finally, to cap the climax, our National Congress passed a pure food bill in which this Pharmacopœia is accepted as the standard and the President of the United States by signing the bill made it law for this country.

Accordingly the system of false atomic weights has become a part of the law of the land and the best work done in the chemical laboratories of the United States must be falsified by the use of the false atomic weights legalized by Congress and the President; and, as if this were not bad enough, as a technical absurdity, the action of our Government reaches much farther; for it includes the condemnation of the broadest principle of modern science: The unity of matter.

History furnishes but one single parallel to this action of a non-scientific governing power condemning a scientific truth and we have to turn back many pages of the book of history, the record of a number of centuries, to reach that single precedent.

It was at the close of the Dark Ages that the Church at Rome (through certain institutions and officers of its own) did what the State at Washington (through Congress and President) repeated at the opening of this, the twentieth century.

St. Louis, Mo.

The Efficiency of Induction Furnaces.

By Joh. Härdén.

In ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, Vol. VII, No. 1, this subject is discussed in an article by Mr. F. A. J. FitzGerald.[1]

In the following article we will give some more particulars of results obtained in a 60-kw experimental induction furnace erected by the Gröndal-Kjellin Company, Ltd., in London, together with a few explanations and comparisons.

It may be useful to first settle the question: What is meant by "the efficiency" of the furnace, and what are the factors which influence the efficiency of the plant?

The theoretical efficiency may be classified as thermal and total efficiency.

We require a certain amount of heat to melt and superheat

[1]See Also Vol. VI, No. 11, p. 439.

a given quantity of steel, and this may be expressed in a number of calories, to be supplied by means of electric power.

The heat required to melt, say, 1 kg of steel, divided by the number of calories supplied in kw-hours will give us the efficiency of the furnace.

The thermal efficiency is derived from the power actually taken up by the charge, including the losses by radiation, slag, etc.

The total efficiency is determined from the total amount of power supplied to the furnace, including the above losses as well as all the electrical and magnetical losses.

The electrical losses are composed of Joulean heat losses in the primary coil, in the leads, and of eddy currents.

The power factor has a great influence upon these losses, because with a low power factor of, say, 50 per cent, we have to supply about 50 per cent more kilovolt-amperes to the furnace than what is actually utilized in the charge. The "wattless current" will increase the electrical losses both in the furnace, the cable and the generating plant without any gain. It is, therefore, essential that the power factor should be high.

We must admit, however, that these losses are comparatively small compared with the total expenditure of power in a large furnace, but they may be a serious item in a furnace of smaller or medium size, say, up to 150 kw capacity.

The magnetic losses are due to hysteresis in the iron core and are influenced by the permeability of the iron, the magnetic saturation and the frequency.

It is, therefore, necessary for the furnace designer to consider the cost of the losses compared with the price of the iron; then it is not always wise to make use of iron of the highest permeability because of its higher price. Where power is cheap, a lower grade of iron may be more profitable in the long run.

A compromise must also be made between the magnetic saturation and the frequency available; but, again, a higher frequency means a lower power factor, so this must be subject to careful calculation based upon actual experience.

The curves shown in the diagram (p. 322) demonstrate the approximate decrease of the power factor at higher frequency.

The magnetic saturation has also to some extent an influence upon the working of the furnace; it is not permissible to follow the usual practice in an ordinary transformer, for several reasons.

Also the mechanical design of the iron core will have an influence upon the efficiency, inasmuch as the lack of uniformity of the magnetic leakage field, caused by the counteraction of the secondary circuit, i.e., the charge, may set up heavy eddy currents in the bandage of a badly designed iron core.

It is rather difficult to determine the electric and magnetic losses separately, as their proportions will be altered with the charge. A full charge will cause a stronger leakage field than a small charge, and vice versa.

The separation is also quite immaterial from a practical point of view. It has been ascertained during a long series of runs that the electrical and magnetical losses together will amount to 5.5 to 6.5 per cent of the total energy.

What will interest the steel maker much more is the total efficiency of the plant, i.e., how much has he to spend in power in order to melt a given quantity of steel, in this way or that.

The chief source of the losses is to be found in heat radiation, both from the open surface of the bath and through the furnace walls. The bath is, of course, protected with slag, and also by means of brick-lined iron covers. But in spite of this, some of the heat will escape.

In the early days the lining was built up of firebrick, but regardless of other troubles, because of their great expansion coefficient, the heat conductivity proved rather excessive.

The lining used to-day is stamped in from powdered magnesite or dolomite, with a heat insulation layer between the lining and the furnace wall; this also serves to compensate for the expansion.

As a rule, the following formula for the calculation of the heat conductivity and thickness of the lining may be assumed to be approximately correct:

$$W = \frac{ta}{l} \, c$$

Where W = amount of heat, expressed in watts conducted from one surface of the wall to the other

　t = temperature difference in centigrades.

　a = mean surface in square meter.

　l = thickness of the wall in meter.

　c = coefficient of specific heat conductivity.

This coefficient may be found for various materials in several handbooks, such as "Die Hütte" and others.

If the amount of the total loss is given in percentage, it is thus easy to calculate the required thickness of the wall by means of the above formula, if the conductivity coefficient of the lining material is known.

In practice, however, the thickness of the lining is much less dependent upon a few more or less kilowatts lost by radiation.

The *total* cost per ton of steel, in dollars and cents, is the important question. The corrosive action of the slag upon the lining, and consequently the life of the latter, compared with the cost of relining and material, is to be carefully considered. Therefore, it would be idle to put down a general rule, as the question must be settled individually in each case.

When the power is usually paid for per kw-year, the stoppage for repairs is also an item which will lower the total year-efficiency. A magnesite lining will last, on an average, for eight to nine weeks, but linings have been in use for as long as three months.

The writer has, in order to minimize this source of inefficiency as much as possible, designed an arrangement with interchangeable hearths, patented by the Gröndal-Kjellin Company, Ltd. In this way it is possible to replace a defective lining with a new one in less than half an hour, while the actual re-lining can be carried out at leisure with cheap labor. Part of the old lining material may be used over again if the slaggy parts are removed.

Care must be taken that the lining is not too porous. A moderately porous lining would have a lower heat conductivity and thus give better efficiency, but in the case of the lining being too porous the steel would gradually penetrate through the inner wall of the furnace in the shape of narrow needles.

These do not cause the steel to flow out because they will soon solidify; but the heat is rapidly conducted from the bath to the cooling mantle, thus lowering the efficiency considerably.

Besides, these needles, if they are allowed to occur, will form an easy path for the magnetic leakage, whereby the electrical efficiency will also be materially lowered. The power factor has been observed to be lowered nearly 20 per cent in a large furnace where such needles were permitted to develop. They formed a huge bundle like a wasp's nest and weighed nearly 100 lb.

The heating up and burning in of the lining also, of course, consumes power which is, in one sense, wasted, but as the lining will last for a comparatively long period and the total time used for this purpose is only about eight hours at about one-half of the normal power, this item is not of great importance. Fuel will have to be spent in any furnace for this purpose. We have therefore, omitted to include this in the following calculations:

A small furnace will of necessity waste a larger amount of power for this purpose compared with a larger furnace. The 60-kw furnace mentioned below will require about 160 kw-hours for this purpose, while only a little more will be needed in a furnace of three or four times the capacity of the former.

We will now set forth the fundamental quantities upon which our calculations are based, so as to enable us to determine the total efficiency in each case.

According to the c.g.s system of units, 1 watt is equal to 1/9.81 kg-m; the mechanical equivalent of heat is 424, or, in other words, 1 calorie is equal to 425 kg-m. Consequently, 1 kw-hour equals 864.5 kg-calories.

The pouring temperature of cast steel may be given at about 1525° C.; some steel may require a higher and some a lower temperature, but this may be taken as an average.

The specific heat of cast steel is stated by Neumann, Jüptner and others to be from 0° C. to 1300° C. = 0.20, and above this in average = 0.48.

Thus we find: — 1300° × 0.2 = 260 and 225° × 0.48 = 108 or a total of 260 + 108 = 368 calories. We may, in order to be on the safe side, say that we require 370 calories to melt and superheat 1 kg of steel, theoretically.

As one kw-hour is equal to 864 calories (in round figures) we should obtain 864 ÷ 370 = 2.335 kg of steel for each kw-hour or that one kilogram of molten and superheated steel would require 0.428 kw-hour, if there were no losses whatever.

From this we are now able to determine the total efficiency by the formula

$$E = 0.428 \times 100 \times W \div K$$

Where E = total efficiency of the furnace,

　W = weight of steel in kilograms,

　K = kw-hours spent.

We reproduce below a few records taken from the 60-kw furnace mentioned before and also some figures from the furnace mentioned on page 10, Vol. VII, of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY.

In some cases, ample time was given for the steel to "set" before tapping, which, of course, has nothing to do with the actual melting.

RECORD OF MELTING—60-KW FURNACE.

No. 1.

Time.	Volts.	Amp.	Kw.	Power factor.	Remarks.
9.00	110	182	18	....	Charge 60 kg
9.05	176	290	43	....	
9.22	192	321	49	0.79	
10.15	180	305	44	....	
10.35	185	318	48.5	....	
11.00	190	325	50	0.81	Teeming

Average kw = 42.08.
Total kw-hours spent = 84.16.
Molten and superheated metal = 60 kg.
Efficiency = $\dfrac{0.428 \times 100 \times 60}{84.16}$ = 30.5 per cent.

No. 2.

Time.	Volts.	Amp.	Kw.	Power factor.	Remarks.
2.25	180	230	35	....	Charge 76 kg
2.40	193	324	50	0.80	
3.00	188	342	49.6	....	
3.30	180	352	49	0.795	

Average kw = 45.9.
Total kw-hours spent = 50.6.
Efficiency = 64.2 per cent.

No. 3.

Time.	Volts.	Amp.	Kw.	Power factor.	Remarks.
2.15	192	325	49	0.785	Charge 32 kg
2.40	192	325	43	....	
2.50	192	325	43	....	

Average kw = 45.
Total kw-hours spent = 26.25.
Efficiency = 52 per cent.

It must be noted that in charge No. 2 a portion of hot steel was left in the furnace from the previous charge, assumed to be about 22 kg. As this was already molten, but became very chilled during the re-charging, the efficiency figure may be somewhat too high in this case, but we are justified in assum-

ing that the average efficiency is between 40 and 50 per cent, taken over a series of meltings.

RECORD TAKEN FROM THE 125-KW FURNACE.

Time.	Volts.	Amp.	Kw.	Power factor.	Remarks.
11.25 A.M.	590	225	105	0.79	Start heating, 381 kg left from previous charge.
11.35	584	240	115	0.82	Charge 91 kg pig iron.
11.45	574	252	118	0.81	Charge 91 kg bar ends.
12.00	569	262	120	0.80	Charge 100 kg scrap ingots.
12.10	567	268	122	0.80	Charge 45 kg pig iron.
12.20	569	270	123	0.80	Charge 45 kg pig iron.
1.00 P.M.	554	272	120	0.80	Ready to teem.

Yield of steel = 372 kg.
Total power spent = 220 kw-hours.
Total efficiency = 72.4 per cent.

As will be seen from the above, the efficiency of this furnace is considerably higher than in the 60-kw furnace, owing to the possibility of treating a much larger quantity of metal in a
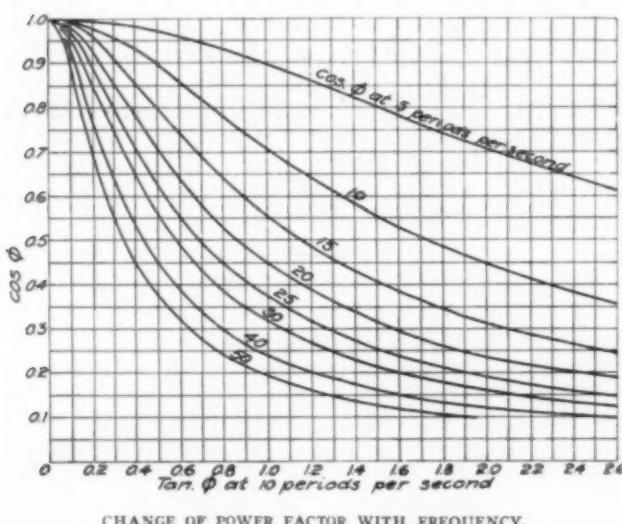
CHANGE OF POWER FACTOR WITH FREQUENCY.

shorter time. In fact, melts have been made in this furnace at which the efficiency was well over 76 per cent with forced melting.

The above figure shows that steel can be made with an expenditure of 590 kw-hours per metric ton or even less, with forced melting.

In ordinary practice, however, the melting period will have to be somewhat prolonged for several reasons.

It has not been found practical to make more than six charges in 24 hours, when a high-grade tool-steel should be produced, even if the furnace was designed to permit 8 or 10 charges.

The reason for this is that the steelmaker requires that the steel should be given what he terms a "killing time"; after proper melting and mixing (which is done automatically in the furnace owing to the strong evolution of the charge, caused by the magnetic action) the steel is usually left in the furnace for some time, at a moderately high temperature. During this time most of the gases are expelled and the charge becomes calm and will not cause blow-holes in the ingots.

Different raw materials may require different "killing time," but records taken over several months run in a larger furnace show that ordinary tool-steel requires about 650 kw-hours per metric ton, while the highest grade may require from 750 to 800 kw-hours in a furnace of 1½ to 2 tons capacity.

Now, if we assume that power will be purchased at a rate of $18 per kw-year, which seems a reasonable figure (in a large steel works, where blast furnace gas is available for the purpose, it may even cost only $12.15 yer kw-year), we find that the kw-hour will cost about 0.2 cent.

Applying this to the above figures, we see that the cost of power for melting one (metric) ton of tool-steel will be $1.30 and $1.60 respectively.

Even if we include all losses caused by stoppage during relining, etc., the melting costs should not exceed $2 per ton, which will be found to compare favorably with the coke-crucible furnace, especially if we consider the great saving in labor, as only three men per shift are required for the operating of a 2-ton induction furnace.

LONDON, ENGLAND.

Electric Furnace in the Iron and Steel Industry

Mr. P. McN. BENNIE, of the FitzGerald & Bennie Laboratories, Niagara Falls, N. Y., lectured, on June 10, at Harrisburg, before the newly founded Engineers' Society of Pennsylvania, on the relation of electric furnaces to siderurgy. He first gave a review of what has actually been done with respect to the reduction of iron and the making and refining of steel in electric furnaces. Since all these matters have been very fully covered in the past in this journal, it is the final conclusions of Mr. Bennie which will be of special interest to our readers.

First, as to high-grade steel, the electric furnace is rapidly becoming a serious competitor of the crucible method, for the simple reason that it is less expensive. Against a high cost for labor, crucible renewals, and the fact that steel must be melted in small units, we have a lower labor cost, small cost for refractories, and the possibility of handling several tons of metal of uniform composition.

Second, as to steel for structural and rail purposes the electric furnace is so far only asking recognition as a useful adjunct to existing apparatus, for doing additional refining or treatment in an economical and expeditious manner. Not a rival, but an ally, in the general siderurgical scheme.

Third, for steel castings, the electric furnace cannot compete with open-hearth castings, but for a grade somewhat better, where additional refining would be required, the electric furnace has decided advantages. For castings of crucible quality the electric-furnace methods will give satisfactory results at less cost than crucibles. In addition for heavy castings the larger quantity of metal which can be treated as a unit is of much more importance.

It is a fact that higher temperatures are at the command of the metallurgists in electric furnaces. Generally speaking, refining is more rapid and thorough with higher temperatures. Whether any good is accomplished by additional refining must be left to the steelmakers to decide.

"I heard it said recently by a metallurgical engineer that product with just as good analysis could be made in any ordinary furnace as in the electric furnace. The truth of this contention is granted, but not the implied conclusion that analysis is the whole story. Given a choice between two steels of identical price and analysis, one of which is known to be the product of the crucible process and the other of the open-hearth process, would any engineer hesitate?"

As to the electric furnace, if it can produce an improvement in quality, worth more than the increased cost, its future is assured. All electric-steel furnaces work under basic conditions, even those used for tool steels. It has been found in Germany, for example, that steel is improved by simply putting it into an induction furnace, leaving it there for an hour or two without attempting any refining by slags, meanwhile supplying only sufficient energy to maintain the temperature. It is believed that this gives dissolved gases an easy opportunity to escape.

Finally, Mr. Bennie expects the following improvements to be made:

Electrodes of larger size, and quality that will reduce the present consumption per ton.

Refractory materials superior to those now in use, and probably themselves the product of electric furnaces, such as fused alumina and other refractory oxides. In electric furnaces where an arc is present there is considerable vapor formed by volatilization of silicon, calcium, calcium oxide, and even iron itself, which vapors are very active chemically, attacking the walls and roof of the furnace. The destruction of the roof in electric furnaces is probably due as much to these vapors as to the high temperatures.

Finally we may expect an increase in size and capacity of furnaces. This development has already started with the 15-ton Héroult furnaces of the United States Steel Corporation.

"When it is considered that electric furnaces charged with molten metal are good for 10 heats daily, it will be seen that with a total daily capacity of from 100 to 150 tons of steel, the electric furnace may fairly be said to have emerged the metallurgical nursery."

Girod Electric Steel Furnace.

As well known to our readers from descriptions in our Vol. VI, pages 428 and 452, the Girod electric steel furnace is an arc furnace like the Héroult, but differs from the latter in one important respect. In a single-phase Héroult furnace there are two electrodes on top, operating in series; the current passes from one electrode in form of an arc into the slag, through the

PAUL GIROD.

slag, and out of it again in form of another arc into the other electrode. In a single-phase Girod furnace there is only one electrode on top, while steel pieces embedded in the bottom of the furnace (water-cooled from the outside) form the other terminal of the electric circuit; the current passes from the electrode at the top in form of an arc into the slag and then downward through the molten charge, leaving the furnace through the bottom.

Considerable details on the working of this furnace were given in Mr. Paul Girod's American Electrochemical Society paper, published in our June issue, page 259, while the general plan and arrangement of the works of the Société Anonyme Electrometallurgique Procédés Paul Girod, erected at Ugine, in Savoy, France—the largest electric steel works now in existence and course of erection—were described in our January issue, page 9.

We are glad to give here, together with the portrait of the distinguished inventor, illustrations of two Girod furnaces installed and in operation at Ugine. Fig. 1 is an 8-ton to 12½-ton furnace; Fig. 2 a 2-ton to 3-ton furnace.

The Girod electric steel furnace is now being used by the following concerns:

Cie des Forges et Acieries Electriques, Paul Girod, Ugine, France.

Oehler & Company, Aaran, Switzerland.

Société An. John Cockerill, Seraing, Belgium.
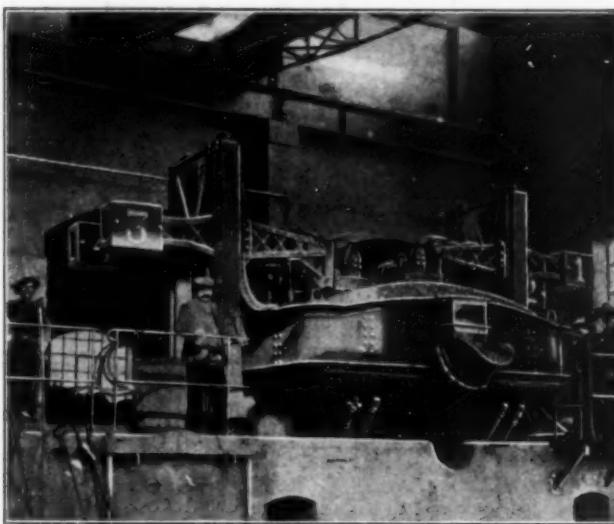
FIG. I.—8-TON TO 12½-TON GIROD FURNACE.

Stotz & Company, Stuttgart, Germany.

Ternitzer Stahlwerke, Ternitz, Austria.

Steirische Gussstahlwerke, Danner & Company, Vienna, Austria.

Poldihütte, Altkladno, Austria.

Marrel Frères, Rive-de-Gier, France.

It is interesting to note, that, as we hear from Messrs. C. W. Leavitt & Company, of New York (the American agents for the Girod furnace), "the owners of the Girod process are ready to guarantee the perfect working of a 25-ton Girod furnace for refining steel previously molten in a Martin furnace. However, M. Girod contends that a comparison of two kinds of steel of exactly the same final composition, but manufactured by different methods, viz., one by molten charge refined in the electric furnace, and the other manufactured exclusively in the

FIG. 2.—2-TON TO 3-TON GIROD FURNACE.

electric furnace from cold charge, will show that the latter gives the best results, and that the metal refined from molten charge will not show the same good qualities, namely, not the same resistance to shock; and with regard to tool steels not the same hardness nor the same tenacity and durability after hardening." (See also p. 263 of our last issue.)

SYNOPSIS OF PERIODICAL LITERATURE.

In addition to the report, found elsewhere in this issue, on the recent International Congress of Applied Chemistry in London, we herewith give abstracts of a number of further congress papers.

Congress of Applied Chemistry.

Evolution in Applied Chemistry.—Otto N. Witt delivered a general lecture on this subject. It was pointed out that the simple daily wants of mankind in a primitive state were supplied by nature. The progress of civilization, however, necessitated a transformation of these gifts, which culminated in the birth of industrial chemistry. In this manner there arose a new creation, which was helped along its way by sound empiricism. Nature was forced to divulge her innermost secrets, and empiricism was quite content to pick up the treasure it might come across in its ramblings through the unexplored regions of science. New fields were continually being opened, and the process was as active to-day as ever. An example of this evolution is to be found in Norway at the present time. A new chemical industry of vast dimensions is being exploited which differs fundamentally from those of older commercial centers. Its factories will have no chimneys nor fires. They will be operated by "white coal," the force of roaring waters. The problem before older engineers was to convert heat into electricity, but in Norway the exact reverse is required. The history of applied chemistry is teeming with examples where the survival of the fittest meant neither more nor less than a a victory of economy. (London *Electrical Review,* June 11.)

Thermochemical Notation.—W. N. Hartley proposes that a uniform system of thermochemical notation be adopted. He has employed the terms "gram heat-unit" and "kilogram heat-unit" in a contracted form, instead of the small and large calorie, in order to avoid any possible misunderstanding as to their values. The abbreviations for the gram and kilogram now recommended for adoption by Lord Rayleigh are gm and kgm. According to Buchanan's notation the gram unit of heat or small calorie becomes a gram-degree Celsius, gm° C, and the large calorie a kilogram-degree Celsius, kgm° C (plural kilogram-degree Celsius, kgm° C). Similarly he recommends to denote the British thermal unit by pound-degree Fahrenheit, lb. ° F. He also recommends that J. H. Pollak's method of writing thermochemical equations be adopted. (From advance sheets.)

"Analyzed Chemicals."—This is the subject of a paper by J. T. Baker (J. T. Baker Chemical Company). "Analyzed Chemicals" represent one of the latest efforts on the part of the manufacturing chemist to furnish the analytical chemist with chemical reagents of the highest degree of purity attainable under conditions limited by skill and economy and labelled in a manner which can be intelligently understood. The common method of designating a chemical as "C. P." has resulted in much confusion owing to the fact that "chemically pure," strictly speaking, is impracticable. A chemical accompanied with a statement of analysis affords both a standard of purity and at the same time a guarantee of quality. The analysis states in definite terms the highest degree of purity attained and is in itself a guarantee in regard to which there can be no misunderstanding. The analysis states in definite terms the amount of impurity present calculated in percentage from samples large enough to obtain a determinable amount of impurity which may be present. Although the amount of impurity present, as shown by the analysis, may be insignificant, it is a source of satisfaction to the chemist, and affords an assurance which cannot be obtained in any other way. The object aimed at is to get away as far as possible from the errors of "personal equation" by getting results down to a mathematical basis. (From advance sheet.)

Photochemical Deterioration of Oil Paintings.—Maximilian Toch refers to the fact that all oil paintings show unmistakable signs of age; the whites turn yellow, and wherever a glaze of asphaltum is used, this turns brown. He showed that linseed oil, in the presence of lead and zinc pigments (principally lead pigments) change the coloring matter in bleached linseed oil, which is xanphophyll, by reduction into chlorophyll, and that when oil paintings that have turned yellow through this reduction are placed in bright sunlight they bleach again into their original condition. He furthermore shows that the tempera painting of the ancients and the method of painting with resins, like dammar, do not produce this age effect.—(From advance sheets of paper.)

Sulphur Dioxide Determination.—T. Lyndon Briggs deals with the determination of sulphur dioxide in dry gases and discusses Orsat apparatus made available for the purpose by use of chromic acid in concentrated phosphoric or sulphuric acid solution.—(From advance sheet.)

Fuel Testing.—In a joint session of Section I and II a resolution was adopted that "the percentage of volatile matter in fuel shall be that which is found by subtracting from 100, the yield of coke, obtained by the method of the American Committee on Coal Analysis—the percentage being calculated upon the pure combustible matter."—(The *Engineer,* London, June 11.)

Fused Silica and Ceramic Castings.—The fine exhibits of fused silica ware of the Thermac Syndicate, described by J. F. Bottomley, and the ceramic castings exhibited by G. Keppeler, attracted considerable attention. The latter are an invention of Weber, of Schwepnitz, in Saxony, and have been improved by Keppeler and Spangenberg. By adding alkali salts to certain clays, a kind of emulsion is obtained which can be poured into moulds. The process is applied for making not only sanitary ware and terra-cotta goods, but also dishes, crucibles and laggings of fireclay, and other refractory products; for instance, the pots in which glass is melted. The diagrams of the machinery which were shown were very simple. The materials were delivered by an elevator into a mixing-machine and then into stirrers, from which the pasty substance was run into molds.—(Lond. *Engineering,* June 11.)

Rubber.—Meyer Wildermann described a technical process for the improvement of low- and medium-grade rubbers. Such rubbers may contain a fair proportion of good rubber; but a comparatively small percentage of resin in the rubber depreciates the product very badly. The reasons are that the resins are unstable and liable to oxidation, that their presence prevents correct vulcanization, and that the resinous rubbers are sticky and cannot bear the vulcanization temperature without running, and have to be mixed with all sorts of ingredients to allow of some vulcanization. Several former processes for extracting the resin were discussed. The process which the author proposed is cyclic and does not aim at separating the whole of the rubber from the whole of the resin. He prepares a series of mixtures of two solvents—say, chloroform and alcohol; the first dissolves only rubber, the second only resin. In applying the process mixtures rich in chloroform are gradually replaced by mixtures in which alcohol predominates; the solution is drained off and the solvent recovered, first, under atmospheric pressure, then in a vacuum, and fresh mixtures are prepared and re-used. Such an extraction takes only 12 hours, and much less solvents than former processes. The valuable rubber remains undissolved and unimpaired, and the resulting product is more uniform than with other treatments.—(London *Engineering,* June 4.)

"Thermic Reactions in Vacuo."—Frank E. Weston and H. Russell Ellis call "thermic reactions" that general class of reactions of which the Goldschmidt thermit reaction is the most celebrated example and which are distinguished by a great evolution of heat and by the necessity of having a certain amount of heat energy imparted before reaction proceeds. Other thermic reactions are the reduction of oxides and sulphides by Ca and of CaO by CaH_2 (F. M. Perkin), the reaction AMg_2Ca, and Al upon MgO, Al_2O_3 and CaO, etc. The

initial energy necessary for starting the reaction can be supplied in different ways. In many reactions the presence of air has a very great influence over the course of the reaction and on the nature of the products; many reactions can be arrested by the exclusion of air and restarted by exposure to air. An initial high temperature is required to start all thermic reactions, and when two oxides are being studied the heats of formation of which are close external heat must be supplied to change the oxygen from one metal to the other. This heat can be obtained from an external source or from the combustion of the reducing agent with the oxygen or nitrogen of the air or both. With a view to ascertaining what part the atmosphere plays, attempts have been made to carry out such reactions in vacuo. They had difficulties in starting such reactions when air was excluded, the various reactions taking place with vigor when air was present. The various mixtures were heated in vacuo by glowing platinum wires up to the melting point of platinum, by iron wires and by igniting a fuse of $4Al + 3Na_2O_2$, but very few reactions took place, and many which started only continued for a short while. The reactions between Al_2 and Fe_2O_3, $4Al + 3Na_2O_2$, $2Mg + Na_2O_2$, $Mg + Na_2O_2$, $3Mg + Na_2O_2$, $Al_2O_3 + 3Mg$, $Mg + SiO_2$, $2Mg + SiO_2$ have all been brought about in vacuo, but always more quickly than in the open air and with different products. A very large number of other mixtures have been tried, but up to the present without success, the difficulty being to produce a great initial "heat density" without which, air being excluded, action will not take place. The work is being continued, and the various mixtures heated before firing the fuse, etc.—(From advance sheets.)

Nickel Bronzes as Anti-Friction Metals.—R. ADAN, of Gand, Belgium, presented a paper on "The Utilization of Nickel-Bronze as Anti-Friction Metals." The abstract did not give any anlysis, unfortunately, but the author stated that bronzes prepared from fresh metals proved far inferior to bronzes made from scrap, probably because in the latter case the metals were in a finer state of subdivision. The specimens were fused three times and then submitted to tension tests, impact tests on Guillery-Frémont machines and Brinell tests. The bronzes took a high polish, resisted the action of alkalies and diluted acids, and were recommended for stuffing boxes, valves, collars, etc.—(London *Engineering*, June 11.)

Aluminium Plating.—E. C. SZARVASY presented an interesting communication on the corroding of aluminium in alcohol. Incidentally, a method has been developed for plating aluminium, which up to now has been an unsolved problem. The bath employed is a solution of a dry copper, nickel or tin salt in anhydrous methyl alcohol. The aluminium to be plated is thoroughly cleaned with a metal polish containing fats. The object of the fat is to protect the clean metal surface from atmospheric oxidation. The metal is then introduced into the bath, the alcohol dissolves the fat, and copper, nickel or tin is deposited in an adherent form on the aluminium surface.—London *Electrical Review*, June 11.)

Thermal Treatment of Non-Ferrous Metals and Steel.—Two papers on "The Thermal Treatment of Non-Ferrous Metals" were read by L. Guillet; the authors were A. PORTEVIN and L. GUILLET. Portevin dealt with alloys of copper, bronzes of copper-tin and of copper-aluminium and the influence of tempering and annealing, considering also the influence of the thickness of the specimens. In brasses the annealing process could, he said, be followed with the aid of metallographic analysis and of Brinell hardness tests. For copper alloys, Portevin concluded, the conditions of melting, the temperature and time of heating and cooling, the rate of cooling, and the disposition of the constituents in the molds had greater influence upon the properties of the alloys than had been attributed to them, and the regulation of these factors enabled us to secure effects which had otherwise been obtained only by the addition of foreign metals. Guillet, in the communication already mentioned, as well as in a further paper on "The

Thermal Treatment of Steels," comprising special steels, likewise accentuated the importance of the time-factor. The same blue tint was, he said, obtained by heating for 10 minutes (always in the air) up to 350° C.,or for 30 minutes to 300°, or for four hours to 250° C.—(London *Engineering*, June 11.)

Ferro-Alloys.—M. CHAPLET referred to the progress made in the production of ferro-alloys low in carbon and to the great value of these in the iron and steel foundries. M. Chaplet pointed out that the carbon in these ferro-alloys was generally present in the form of a double carbide of the iron and the rarer metal, and that in many cases these double carbides would be found in the form of isolated grains, and would become centers of pitting and corrosion in the finished steel. This was found to be especially the case with Martin steel deoxidized with ferro-manganese carbide. The author then referred to the Chaplet furnace in which ferro-alloys are now produced at Allevard-Giffre. This is an electric furnace of a modified form in which the use of a carbon base or "sole" has been dispensed with, in order to diminish the percentage of carbon in the finished alloy. The author also pointed out the advantages of selecting a deoxidizing agent which would yield a very fluid slag at the temperature of the metal to which it was being added, and named the ternary alloys, containing silicon, as the most valuable in this respect.—(*The Engineer*, London, June 11.)

Recording Calorimeter.—C. V. DRYSDALE described a recording calorimeter with the following essential details of structure: A thermopile is constructed of strips of iron and of constantan, each of which forms two sides of a rectangle, and is riveted and hard-soldered to the next element. The result is a rectangular spiral of 15 elements with one set of junctions at the top, and the other set at the bottom. Insulating strips of mica are inserted along the vertical sides of the spiral, which is clamped between two asbestos boards by means of metal frames. The whole arrangement thus forms a lamp chimney. The flow of air takes place between the strips at the bottom and the top where the mica insulation is absent. In operation cold air enters at the bottom, passing through the cold junctions to a combustion jet. The hot products of the flame then traverse the interstices between the top strips, and the e.m.f, developed by the pile indicates the rise of temperature resulting from combustion. The resistance of the pile is low, and the power produced is sufficient to obtain a trace on a recording instrument. The galvanometer is a very robust double-pivoted instrument, the pointer of which carries the recording pen. The results obtained are uniformly good.—(London *Electrical Review*, June 11.)

Smelter Smoke Troubles.—CHARLES BASKERVILLE discussed the legal status of industries giving rise to noxious gases and the smelter smoke question in the United States. He gives a review of the American laws regulating the pollution of the air with noxious or offensive gases, with a discussion of the cases in point of rule, general decisions, and the remedies proposed for the suppression of such nuisances. It is shown that there is neither entire uniformity nor definiteness of statement in the codes of the several States, and that no specific regulations obtain. After a discussion of the foreign laws on the subject, the solution of the "smelter smoke question" is considered. It is pointed out that considerable progress has been made by some manufacturers toward the installation of waste recovering devices, and that the enforced use of such contrivances by the enactment of a Federal law regulating the amounts of waste gases to be permitted to pass into the air will alone solve this great national industrial problem. However, the geographical and meteorological conditions prevailing in the various States must be carefully considered. The paper is replete with legal citations.—(From advance sheet of paper.)

Cryolite.—C. F. JARL explained the meaning of cryolite and its uses for the production of opalescent glass, and as a constituent of leadless glass, in addition to its use as a solvent of alumina.

RECENT METALLURGICAL AND ELECTROCHEMICAL PATENTS.

In view of the extensive convention and congress reports in our last and in our present issue, a large number of abstracts of both metallurgical and electrochemical patents must be held over for our next issue, in which our records of these departments will be brought up to date.

Steel for Armorplates.—The cementation if armorplates has resulted in considerably increasing the resistance to uncapped projectiles, in comparison with the homogeneous armorplates previously employed. But when attacked by capped projectiles, they offer but a relatively small resistance and one which is far from uniform. Eugene Schneider, of Le Creusot, France, patents an alloy steel, and claims that homogeneous armorplates made from this steel present a more uniform resistance to the attack of uncapped projectiles, and that they also offer greater resistance to capped projectiles than the best armorplates heretofore known. This steel contains "in addition to the iron, per hundred parts, 0.30 to 0.50 carbon, less than 0.350 manganese, 3 to 5 nickel, 0.5 to 1.5 chromium, and while the metal is in fusion, from 0.5 to 1.5 per cent of molybdenum or 1 to 3 per cent of tungsten, or again, 0.2 to 0.5 per cent of vanadium are added. The presence of the molybdenum, tungsten or vanadium separately or combined in twos or all three added together to the nickel and chromium in the steel, advantageously replaces the high percentage of carbon in the impact face of cemented armor plates, because it makes it possible by any convenient process of tempering to obtain in regard to this face a hardness sufficient to crush the projectiles and preserve all the desirable malleability in the metallic mass for avoiding cracking on firing." (925,659, June 22.)

Electric Steel Refining.—O. Thallner, of Bismarckhutte, Germany, who has made a special study of steel refining in the Héroult furnace (our Vol. VI, page 26), proposes the following combination process: Steel previously refined in a Martin, Bessemer or Thomas furnace, is first treated in an electric furnace provided with a basic lining, such as lime. In this furnace the refining is pushed so far that the metal is perfectly free from carbon, manganese, silicon, phosphorus and sulphur. In this condition the metal contains not only considerable quantities of oxygen in the form of oxides, but it possesses also the capability of taking up oxygen when coming in contact with the air during pouring. This unfavorable property can be avoided by carrying out the last stage of the process in an acid-lined electric furnace. This stage comprises removal of the oxides contained in the bath owing to the action of the acid hearth and then carbonization. Also the addition of alloys can take place in the acid-lined electric furnace much more favorably than in a basic-lined furnace. Such addition may be, for example, silicon, chromium, tungsten or nickel. By means of this combination it is possible to produce a product which possesses a perfectly compact structure with only the smallest possible content of manganese and carbon or with practically none of these constituents. (925,612, June 22, 1909.)

Lash Steel Process.—With respect to the Lash process which has been covered very fully in our columns (see, for instance, our last issue, page 268), two recent patents granted to Mr. Horace W. Lash are of interest. In one of them it is stated that the use of solid or molten pig iron in the lower part of the charge is of the greatest advantage in practical operation. The first claim refers to "a process of smelting iron oxides which involves charging into a furnace a smelting mixture containing finely divided oxide of iron, finely divided cast-iron and carbonaceous material, and also disposing in said furnace a quantity of pig metal in proper manner to form a bath beneath the smelting mixture and applying a smelting heat to the charge. (924,677, June 15, 1909.)

Mr. Lash's second similar patent refers to the application of the electric furnace to his process. A suitable smelting mixture may consist of 54 per cent oxide of iron (ore), 27 per cent cast-iron borings (or granulated pig iron), 8 per cent crushed coke, 4 per cent coal-tar pitch, 4 per cent sawdust, and 3 per cent crushed limestone. This mixture is made up into briquets with the aid of the coal-tar pitch as binder. The briquets or lumps are charged into an electric furnace. The sawdust disappears and leaves the mass porous. Then part of the coke and the metalloids and easily oxidizable metals contained in the finely divided cast-iron unit with the oxygen of the ore and reduce the ore to metallic iron. The fused iron collects on the bottom of the furnace; in view of the non-oxidizing atmosphere of the electric furnace it will be high in carbon and easily fusible. A portion of the bath is then tapped from the electric furnace into an adjacent gas-fired refining furnace. But part of the molten iron is left in the first electric furnace and a fresh supply of the above-described smelting mixture in form of lumps or briquets is added. "The furnace being already at a high temperature and the bath of retained metal containing oxidizable metalloids capable of aiding in reducing the iron oxide of the smelting mixture, it is found that within a short time the entire mixture is reduced and the heat again ready to be tapped, so that a portion of it may be run into an adjacent furnace for further treatment, while a portion of the bath is again retained in the furnace and the smelting operation is continued in the same manner as before. (924,676, June 15, 1909.)

Deposition of Metal on Porcelain and Earthenware.—Quentin Marino metallizes in the following way vitreous, porcelain, earthenware and similar surfaces so that metals can be electrolytically deposited upon them. The surface is first roughened or rendered matte, for instance, by means of hydrofluoric acid. A cold solution is then made by putting cuprous oxide into a solution of nitrate of silver, whereby a gray substance is quickly formed consisting of filiform silver and basic nitrate of copper

$$6\,Ag + 2\,Cu\,(NO_3)_2 + Cu_4O_4\,(NO_3)_2.$$
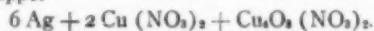
This gray substance is then dissolved into hydrofluoric acid, and the solution so formed is applied, say, by means of a brush, to the roughened surface. In order to insure its adherence, the inventor reduces the copper and the silver in the fluoride to the metallic state. For this purpose he dusts the surface, while it is wet, with the last-mentioned solution, with a mixture of metals, or with one metal only, in a finely divided state so as to reduce the silver on the one hand and the copper on the other, both of which latter are combined with the fluoric acid. A mixture of powdered copper and zinc may be used, or a powder of copper with either iron, nickel, cobalt, cadmium, lead or bismuth, the copper and zinc reducing the silver, while the zinc, iron, nickel, cobalt, cadmium, lead or bismuth reduce the copper. Or powdered zinc may be used alone, as it reduces both the silver and the copper. The surface thus becomes coated with a mixture of silver and copper in the form of a very thin film sufficiently continuous to be electrically conducting for the purpose of receiving an electroplating deposit. Before starting electrodeposition it is preferable to rube the surface briskly when dry, with a brush or the like, so as to polish it. (935,365, June 15, 1909.)

Tantalum.—According to Werner von Bolton, the pioneer of the metallurgy of pure tantalum and of the tantalum lamp, tantalum can be hardened by additions of 1 to 10 per cent of silicon. By adding 2 or 3 per cent of silicon, for instance, a material of great ductility and considerable hardness is obtained. (925,988, June 22.)

Fixation of Atmospheric Nitrogen.—Demetrio Helbig produces a long arc for the purpose of oxidizing atmospheric nitrogen. Compressed air is projected by two opposite nozzles arranged in line, against an arc between suitable electrodes, whereby two sheaves of flame are produced spreading out along the electrodes in a plane normal to the direction of the nozzles. A modification for three-phase currents, producing a flame-disk, is also described. (926,413, June 29.)

High-Pressure Oxy-Acetylene Welding.

By Henry Cave.

It is not generally known in this country that three distinct types of oxy-acetylene torches were developed in France. These are distinguished mainly by the different pressures under which the acetylene is used, being termed, respectively, low, medium and high pressure.

The low-pressure torch, which uses acetylene at not over 2-lb. pressure, and often much less, is well known in this country; but as the high-pressure torch—which uses an equal pressure of both oxygen and acetylene, which may be as high as 25 lb. per square inch, necessitating the use of dissolved acetylene in cylinders—was never introduced into this country, what in
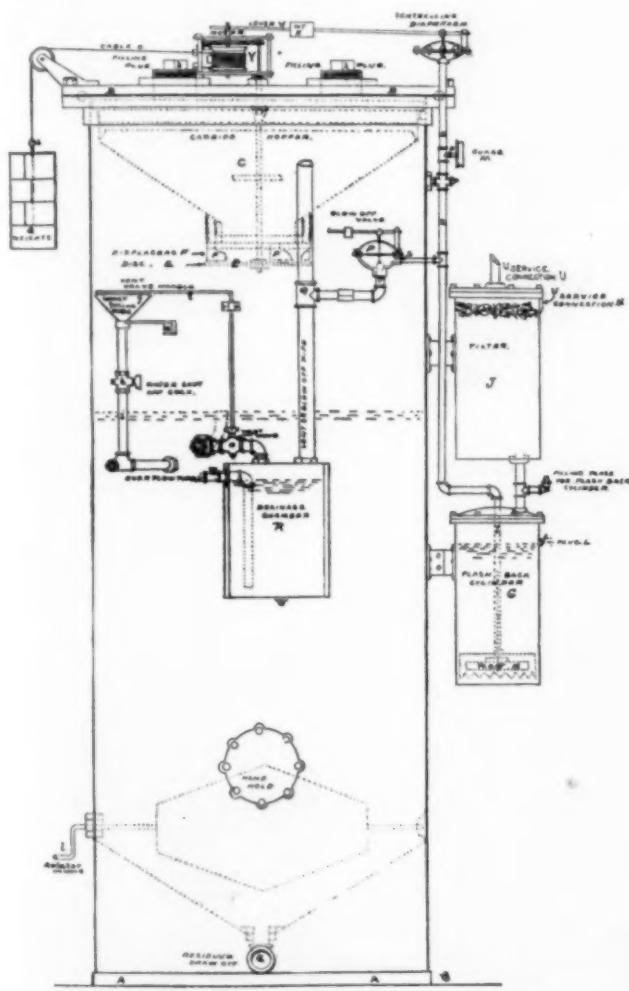

FIG. 1.—OXY-ACETYLENE WELDING SYSTEM.

France is termed the medium-pressure torch, using acetylene from a generator, as shown in Fig. 1, at pressures up to 10 lb. per square inch, is known here as the high-pressure system.

In an article entitled "A Comparison Between Welding Systems," which appeared in the May issue of this publication, it was stated in reference to the high- and low-pressure torches "of the two systems the low-pressure system of welding has undoubtedly been most generally adopted and is now gradually superseding the older system." The author of this article must have had the real French high-pressure system in mind, as both in France and in this country the high- (medium) pressure system is rapidly superseding all others, even to the extent of replacing existing low-pressure equipments. There are more makers of the low-pressure equipment due to the fact that there are very few patent restrictions, and these have not been de-

fended. The high- (medium) pressure system, however, is well protected.

There are probably more small users of the low-pressure equipment, as cheap equipments are on the market, but practically all the large users have installed the high pressure owing to the economy of operation and stronger welds produced.

This is shown by the attitude of the United States Navy Department, who installed the high-pressure equipment after ex-
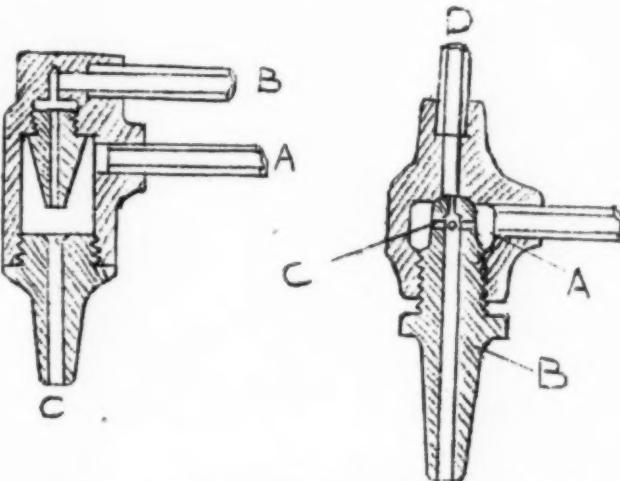
FIGS. 2 AND 3.—LOW-PRESSURE AND HIGH-PRESSURE TORCH.

haustive tests of all kinds, and have placed several duplicate orders since the first plant was placed in operation.

When one compares the methods of mixing the gases in the torches of the two systems, the reason of the economy and efficiency of the high-pressure system is obvious.

The low-pressure torch operates on the well-known injector principle, the general idea being shown in the diagram, Fig. 2, in which the acetylene comes in at A under no appreciable pressure, the oxygen supply passing through B. It can be readily seen that the force of the oxygen under considerable pressure will draw a certain proportion of acetylene along with it out through the nozzle C, where it burns.

But the mixture thus produced is not homogeneous, the gases being stratified. This causes a ratio of 1.80 of oxygen to 1.0 of acetylene to be required to give the correct flame, whereas the high-pressure torch only requires 1.28 of oxygen to 1.0 of acetylene to give the same flame. This is due to the close and intimate mixture of the gases obtained by the two gases striking together at right angles, both under appreciable pressure.

The means by which this is carried out can be seen in the section of the high-pressure torch, shown in Fig. 3. The acetylene passes through the flash-back chamber in the handle and through the large tube into the annular space A around the detachable tip B, which it enters through the small radial holes C.
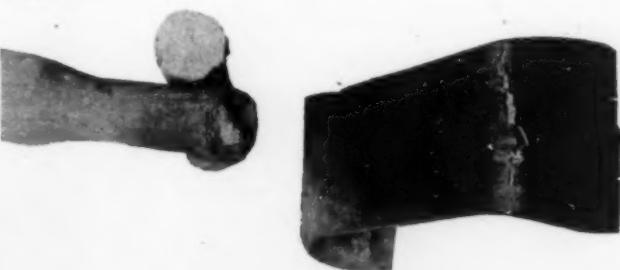
FIGS. 4 AND 5.—EXAMPLES OF WELDS.

The oxygen passes through the small pipe D into the detachable tip through a hole in the end, strikes the four incoming jets of acetylene at right angles, and thus produces the homogeneous mixture before spoken of, not only resulting in a saving

of oxygen of nearly 40 per cent, but owing to the reduced oxidation of the metal, giving a much stronger weld and materially increasing the elongation.

Owing to the fact that the amount of acetylene passing into the tip is positively regulated by the four radial holes a correct mixture is produced under all conditions. This is not the case
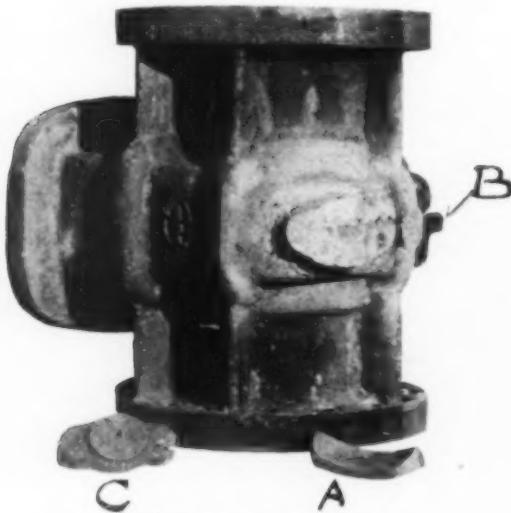
FIG. 6.—PIECE TO BE REPAIRED.

with the injector type of torch, owing to the fact that the amount of acetylene drawn in varies as the square of the velocity of the oxygen, and this may be changed by the expansion of the nozzle, or by particles of metal adhering to it. The operator has, therefore, to keep constant watch on the condition of the flame or bad welds will result.

Unfortunately those in charge of plants in this country know very little of the possibilities of this process, and therefore the general introduction of the tool (for such it really is) into this country is very slow, and this is helped very little by the majority of the technical articles which appear from time to time, as they deal mainly with the equipments on the market or with comparative strengths of welds, instead of describing and illustrating work that has actually been carried out successfully, which is far the best way to impress those likely to have use for the system.

The publication of comparative strengths of welds is, of course, useful, but often very deceiving, as the tests frequently compare the strength of welds with that of the original material which has often had a mechanical strength imparted to it by rolling, which is, of course, removed by heat irrespective of whether the part has been welded together or only heated.
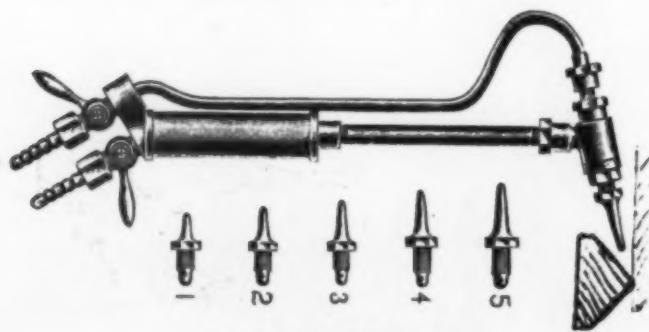
FIG. 7.—REPAIR WITH TORCH.

To get a correct comparison of the actual weld it would be fair to give both the welded and the original piece the same heat treatment. A short time ago an article was published giving the strength of the seam of kitchen boilers welded by electricity and by the oxy-acetylene process which showed unfavorably for

the latter. But the tests were based on electric welds made in a large and expensive machine specially constructed for the purpose, whereas those made by the oxy-acetylene torch were the result of a few experiments by hand, so that neither the cost nor strength showed favorably.

It would, of course, be possible to rig up to do this work by the oxy-acetylene process in a machine so that much better results could be obtained.

A good idea of the strength of a steel weld is obtained by the piece shown in Fig. 4, which shows two pieces (1½ in. x
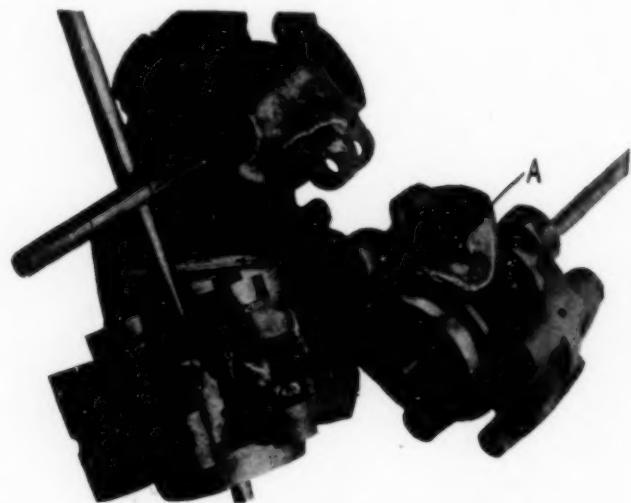
FIG. 8.—REPAIR OF AIR-HOIST CYLINDERS.

5/16 in.) welded together and then hammered out cold until cracked. As can be seen, the crack first occurred away from the weld, the piece being increased in width ¾ in.

Very little has been said of the strength of cast-iron welds, but these show up favorably, as can be seen in Fig. 5, which shows a test piece which broke at a flaw in the weld under a tensile strain of 25,000 lb. per square inch, which is very close to the maximum strength obtainable in ordinary gray iron.

For repairs, which form by far the largest field for the process at the present time, the strength of the weld per square inch does not often count for a great deal, as in the majority of cases

FIG. 9.—WELD OF BRONZE PINION.

metal can be built up over the weld so as to remove all possible doubt of its holding, even if the strength per square inch is much less than the original metal.

This is well illustrated in Fig. 6, which shows a 10-in. gate-valve body made from a steel casting which, after being machined up, was found by the Chapman Valve Company, of Indian Orchard, to be short of a boss. The steel foundry had failed to make use of the loose piece on the pattern provided for this purpose. As it was necessary to find some way out of the difficulty, the problem was solved by sending the castings

to the Autogenous Welding Equipment Company, Springfield, Mass.

They had the steel forging, shown at A, Fig. 6, made so as to form as large a part of the boss as possible. The flame of the oxyacetylene torch is very small, the tip used for this purpose giving a welding flame that is only about ⅜ in. long and ¼ in.

FIG. 10.—REPAIR OF TRANSMISSION CASE.

in diameter. It is, therefore, necessary that the flame should come in contact with every drop of metal welded, it not being possible to make a lap weld. Thus it was necessary to make the forging A V-shaped, so that it would form a groove when placed against the wall of the casting to allow the flame to reach to the center, as is shown in Fig. 7.

It was first of all necessary to cut off a lug corresponding to the one shown at B, with the cutting torch. This lug was put on the pattern for the purpose of locating the loose piece which is shown at C. The forging was then held in position and

FIG. 11.—EXAMPLE OF STEEL PLATE WELD.

the torch applied, metal being added from a low-carbon steel wire to fill up the groove and build up the required shape.

The boss was then faced up and showed good, sound metal. It can be readily realized from this job what a boon this equipment will prove to the machine shop, as everyone knows the uncertainty of obtaining sound steel castings, and all these defects can be satisfactorily taken care of with the oxy-acetylene torch.

The repairs to the air-hoist cylinders, shown in Fig. 8, give a good idea of what can be accomplished in this line with cast iron. The chalk marks show where the welds occurred, and the parts shown at A being missing, a new piece was made up and welded in. The saving in this case alone would represent

a pretty good rate of interest on the investment in installing an equipment.

Fig. 9 shows a weld in a bronze pinion 5 in. in diameter, the tooth marked A having been broken out by the pressure of the key.

Fig. 10 shows the upper and lower parts of a transmission case which were welded in 14 different places, including a lug welded on at A. Even though these parts were so badly damaged, the cost of the work made a considerable saving over a new case.

What can be accomplished with plate steel is well illustrated in Fig. 11, which shows a gear cover made completely of steel, the bosses and brackets being welded on; and those who have had trouble with the breaking of the light cast-iron ones usually supplied will appreciate this improvement.

The photographs are from work carried out by the Autogenous Welding Equipment Company, Springfield, Mass., with their Davis-Bournonville high- (medium) pressure torch.

Recording Thermo-Electric Pyrometer.

A new electric recording pyrometer, distinguished by simplicity of operation and construction, has been recently designed by Messrs. Edward Brown & Son, of Philadelphia, Pa. While the recording device is specially constructed for use in conjunction with a thermo-couple as a thermo-electric recording pyrometer, this type of recording gage could be used for very accurately recording pressures of steam and blast, volts, etc.

As a pyrometer, the complete equipment consists of a thermo-couple of two nickel-alloy rods suitably insulated and protected, the recording electric pyrometer, and the leads or wire for connecting the thermo-couple and the recorder. The leads are commonly of any length from 100 ft. to 500 ft., and very frequently the same thermo-couple which generates the current
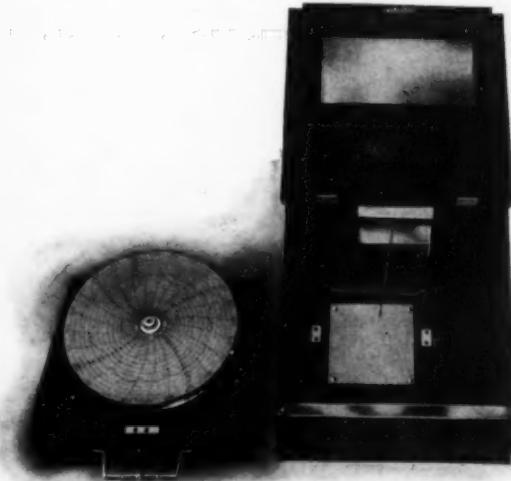

FIG. 1.—DRAWER (WITH CHART AND CLOCK MECHANISM) WITHDRAWN ON THE LEFT.

for the recorder also actuates an indicating instrument on the same circuit, but located near the furnace for the operator's assistance.

The electric recording pyrometer gage consists of a milli-voltmeter system carrying a small drop of ink on the pointer or needle. As this milli-voltmeter system is in a horizontal position, there is no change in weight or position of the pointer with an increase or decrease of ink. A large 8-in. chart of stiff white paper is raised once a minute by a powerful eight-day clock and touches the ink pen, making a small dot on the
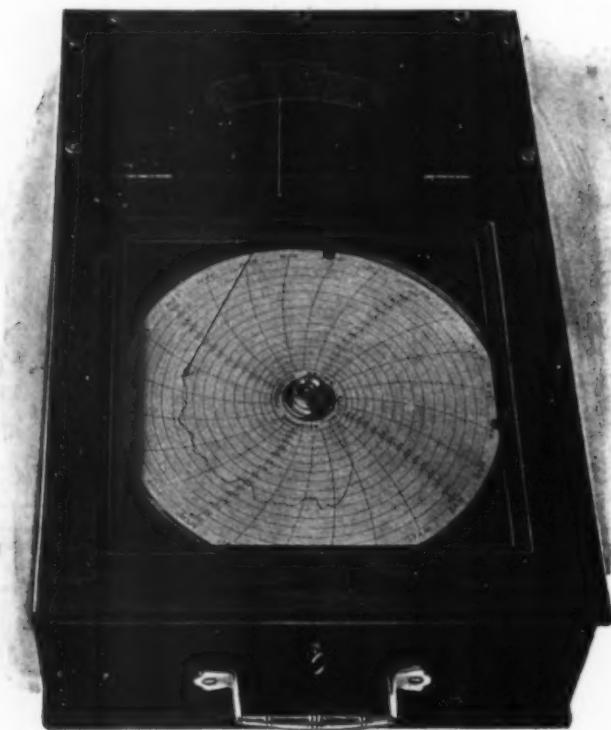
FIG. 2.—RECORDING PYROMETER.

chart. These continuous dots form into a fine line, and as the pen is only in contact with the chart a very short time, the pointer is able to fluctuate readily with the rise and fall in temperature. This momentary contact with the paper is neces-sary in an electric pyrometer, as the milli-voltmeter system has not enough power to pass across a paper in which it was in constant contact.

In order that the chart may be readily removed from the instrument without the danger of striking the pointer or necessitating the moving of the system, the chart and clock mechanism are carried on a drawer which can be withdrawn. This drawer is carried on ways or guides, causing the drawer to be lowered as it is drawn out and preventing the pointer drag-ging a line across the chart. The drawer can either be with-drawn part way, or can be withdrawn entirely and the chart removed and a fresh one placed in position. It is a much
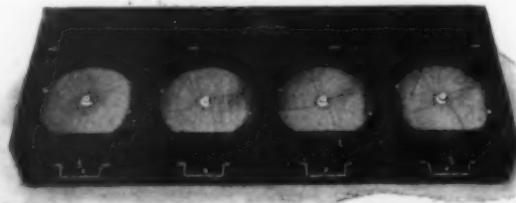
FIG. 3.—QUADRUPLE PYROMETER FOR FOUR FURNACES.

simpler matter to change the charts on a recording pyrometer when lying on a table or shelf than in the recording case.

Once a day when changing charts, a drop of ink is placed in the recording pen with a dropper or pointed article. Occa-sionally also it is desirable to pass a camel's-hair brush, damp-ened with water, through the recording pen in order to clean

the pen and insure a fine ink line. To enable this to be easily attended to, a frame is raised from the base of the recording instrument as the drawer is withdrawn and forms a rest for the pen-pointer. Although the parts of the recording instru-ment are well protected by the case, the milli-voltmeter and the clock mechanism are both enclosed in metal cases as an addi-tional protection from dust.

Where it is desirable to record the temperature of several furnaces, these recorders can be supplied for two or four fur-naces, all records being made in one case.

The recording electric pyrometer can be supplied by the manufacturers for any desired range in temperature, and the record charts can be made to revolve once in 24 hours or 7 days, if preferred.

The last diagram shows a greatly reduced record chart printed in one color only. This chart shows the form of dotted red line made by the Brown recorder and incidentally shows that the fireman attending this furnace was now "on the job" for several hours during the night, and the temperature in consequence dropped rapidly.

The Brown electric recording pyrometer has already been
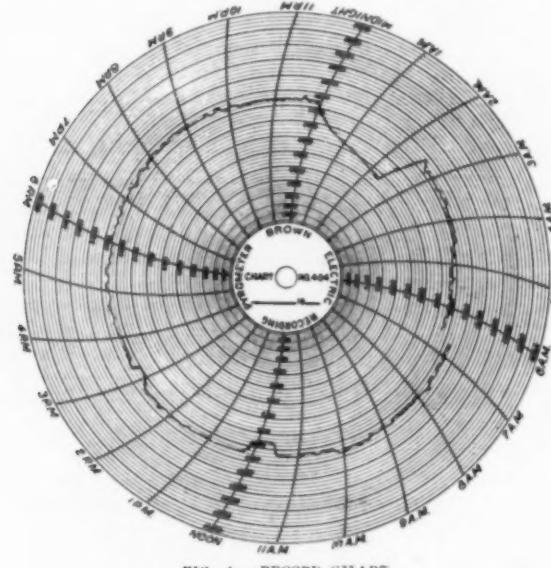
FIG. 4.—RECORD CHART.

supplied for use at a number of blast furnaces and for anneal-ing ovens, glass-melting furnaces, brick kilns, and other opera-tions where a clear record of the temperature is desirable.

Fuel Engineering.

Largely through force of circumstances the engineer rather than the chemist has been looked to as the expert in considera-tion of efficiency of fuel. But the broad field of fuel engineering must include mine inspection, expert knowledge of methods of preparation, inspection, sampling and testing of coal, power-house practice, smoke abatement, the design of power plants, gas-producer practice, and acquaintance with the manufacture of illuminating gas. In a word, the knowledge required is a combination of that independently possessed by the mechanical engineer, the chemical engineer and the mining engineer. As it is practically impossible that a single individual should pos-sess such a diversity of knowledge, it is evident that the best results will be obtained by the co-operative work of a number of experts, each trained and experienced in his particular branch of the work. But such opportunity for co-operation is only warranted in a large and fully equipped organization.

In this connection, and as indicative of the trend in fuel en-gineering, it is interesting to note that Mr. Arthur D. Litttle, Boston, Mass., has recently perfected such an organization in connection with his laboratory of engineering chemistry. The

staff includes as its chief a mechanical engineer and as principal assistants a chemical engineer and a mining engineer. All of these individuals have had extended experience, including connection with the fuel-testing plants of the United States Geological Survey. Three other assistants on the chemical side of the work have had similar, though less extended experience in connection with the testing and use of fuels.

New Revolving Stand for Electrolytic Analysis.

The work of Dr. Edgar F. Smith and others has demonstrated the great saving of time in electrolytic analysis that may be accomplished by using a rapidly revolving platinum disk as
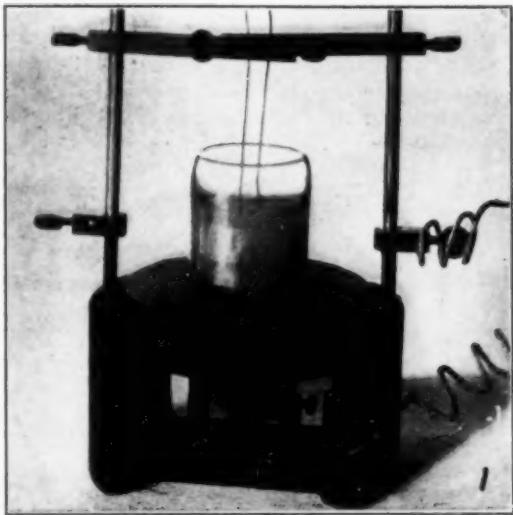
FIG. 1. REVOLVING STAND FOR ELECTRO-ANALYSIS IN OPERATION.

an electrode. The mechanical arrangements are, however, rather cumbersome and expensive. To overcome these objections, Mr. C. J. Reed, Twenty-third and Hamilton Streets, Philadelphia, has brought out an apparatus which is very simple and inexpensive, doing away with the necessity of a separate motor and belt. The complete apparatus is shown in operation in Fig. 1 and ready for operation in Fig. 2. The various parts unassembled are shown in Fig. 3.

The apparatus consists of a platform revolving on a vertical
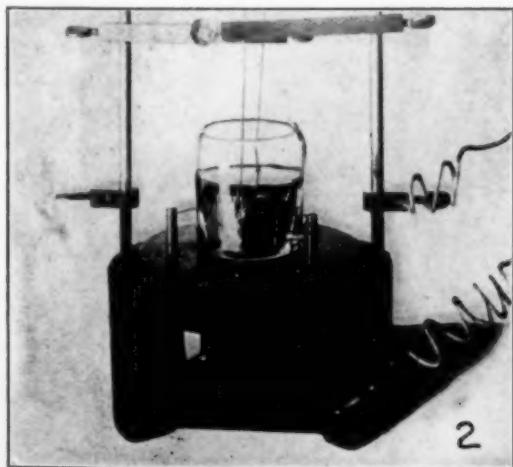
FIG. 2. APPARATUS READY FOR OPERATION.

shaft, the platform itself being the armature of a motor. The beaker containing the solution to be electrolyzed is centered automatically on a floating disk, which rests on and covers the

platform. Electrodes of any form and material may be used. Contact with a mercury electrode may be made through a wire passing through the glass beaker or through a platinum wire sealed into a glass tube and inserted from above. The speed is adjustable through a wide range (10 to 1000) by turning a
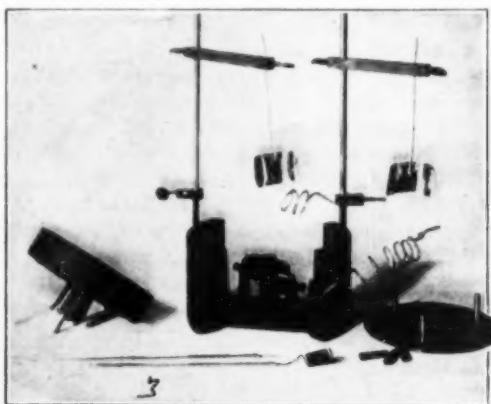

FIG. 3. VARIOUS PARTS OF APPARATUS.

thumb-screw. The motor consumes only from 3 to 5 watts and may be operated by the same current used in the electrolysis or by any separate source. In Fig. 1 the current used in electrolysis also operated the motor in series with the cell.

Tinol, a New Solder.

While the process of autogenous welding by means of the oxy-acetylene blowpipe, or by the thermit reaction, is forging ahead in a very encouraging manner, the time-honored art of soldering is not standing still, as will be seen from the following description of tinol, a new solder which originated in Germany and is now being introduced by the American Tinol Company, 2100 Fairmount Avenue, Philadelphia, Pa.

Autogenous welding means to make a joint directly out of the two surfaces to be joined together, without any foreign material, whereas the characteristic feature of soldering is the use of a foreign material in the solder. While both operations are thus fundamentally different, some principles are the same, the most important one being the necessity to prevent oxidation while making the joint. In soldering this is done by means of a flux which prevents direct contact of the joint with the air.

Until recently the practice was to moisten the carefully cleaned joint with some acid flux, and then flow melted solder (lead-tin alloy) along the joint by means of a heated and tinned soldering iron or copper. If the acid was not carefully neutralized after the joint was completed, a slight remaining excess was certain to corrode the joint and this in some cases proved disastrous. To overcome this, powdered rosin was substituted for the acid flux; while this cured the danger of acid corrosion, the difficulty of making a good joint was greater and the work was apt to be sticky, and not as neat.

As is well known to every metal worker, all alloys of lead and tin, on melting in contact with air, form oxides or dross. The presence of such oxides prevents metallic union of the solder with the metal to be joined. The so-called fluxes serve to protect the melting solder against direct contact with the air and hence against such oxidation.

Tinol is a new solder. It is sold in form of a finely granulated solder, each grain coated with a fatty organic substance which is neither acid nor alkaline. This coating or flux begins to melt before the solder, but is not completely evaporated until the solder has set; it thus protects the solder fully against oxidation during the entire operation.

Practice has shown that when using tinol solder with such materials as tin, lead, brass, and copper, no special cleaning as

by scraping or dipping is necessary; if the joints look clean to the eye, that will be sufficient. Iron and steel must be cleaned of rust and scale.

The mixture of granulated solder and fatty flux forms a paste called "tinol paste." It is of a consistency that allows easy application by a knife blade, glazier's spatula, stiff bristle brush, or even with the fingers. The paste is marketed in tin cans.

The essential feature is that this tinol paste is applied cold to the cold joint. This has various practical advantages. For instance, if a number of joints, for instance in a cable, are to be made, they are first made cold by a brush or knife, and then the joints are finished by quickly passing from joint to joint with the heating torch. Or internal heating may be employed by passing a sufficiently strong electric current through the cable to melt the solder and finish the different joints. Whenever this method is applicable, it gives particularly good results, due to the heat passing from the inside to the outside.

As tinol paste is applied to the cold joint, the awkward handling, resulting from the need of holding the wire (frequently necessary in confined places) and at the same time applying the solder and heat, is avoided; a helper is, therefore, never needed, and the work even in confined quarters is rendered easy.

Droppings, which with ordinary solder are practically unavoidable, are absent with tinol, since experience soon teaches just how much paste to apply in the cold state to insure the filling of the joint and no more.

As it is convenient for some work to use solder in stick and in wire form, tinol is made up also in rods and wires of different sizes, ranging from 5/6 in. down to 1/32 in. These rods and wires are all hollow and contain the same flux used in the tinol paste.

Any source of heat may be utilized, as a gasoline or alcohol torch, hot poker, the usual copper, etc. For light work an ordinary wax match will answer. One advantage of the fine granulation of the solder is that much less heat is needed than with bar solder, since each grain melts more readily.

The German postoffice, in comparative tests at Hamburg on making joints on telegraph wires, found that by the use of tinol the quantity of solder required and the average time of making a joint was very considerably reduced. Resistance tests showed that the conductivity of tinol joints is as high as that of the wire itself.

Broad surfaces can also easily be joined by means of tinol solder. Brushing the paste onto broad surfaces, bringing these together under the requisite pressure and heating in gas furnaces has given very good results for quantity work. For smaller quantities pressing between heated tongs is a neat and effective method.

For narrow joints in sheet metal work the paste is applied to the edge of the joint and then heated in any convenient way, by torch, soldering iron, etc.

For wider joints, the paste is thinned down with a little water and applied with a stiff bristle brush. This is then heated with a torch, or otherwise, as may be convenient, until the metal glistens; in this way the entire surface of the joint is at one operation thinly and uniformly coated with clean tin. A second application of paste is then made, and the parts laid together under pressure and heated. A perfect union of the entire surface is the result.

It is easy in this way to get perfect joints of several inches in width between thin and thick brass, copper, iron, steel galvanized metal, nickel-plated metal, lead, etc. Nor need the metal to be joined be similar; perfect joints between any dissimilar metals of those mentioned are readily made.

Absolutely tight connections for piping are made by smearing the threads with paste, screwing together, lightly heating and then screwing up solid while hot. This use in the pipe work led to its application as a nut lock. A light covering of the screw threads with paste and heating with a torch while screw-

ing home results in so intimate a union that the body of the bolt twists off before the nut comes loose; but when loosening is required, heating with a gasoline torch makes that easy.

The American Tinol Company, of Philadelphia, introduces tinol in the shape of tinol paste, tinol rods, and tinol wire, and varying degrees of softness, the proportions of tin and lead varying between 100 per cent tin and 20 per cent tin to 80 per cent lead.

Electric Resistance Pyrometer Operated by Telephone.

While the thermo-electric pyrometer with its wide range of temperature (up to 1600° C., or about 2900° Fahr.) has found many useful applications in various industries, the electric resistance pyrometer, suitable for temperatures up to 1200° C, or about 2200° Fahr., also begins now to find much favor, especially in cases where a high degree of exactness is required. The chief endeavor of resistance-pyrometer designers has been
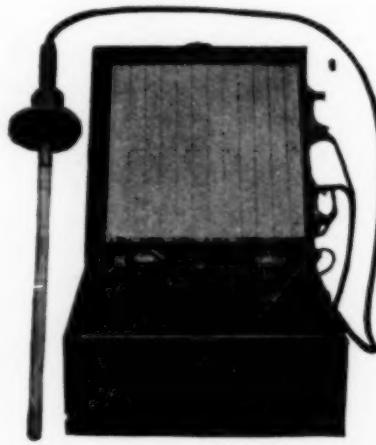
RESISTANCE PYROMETER OPERATED BY TELEPHONE.

in recent years to develop a thoroughly practical instrument, which can be readily operated in commercial work.

Messrs. Eimer & Amend, of New York, have just placed on the market an instrument of this kind. It is operated by telephone and is suitable for temperature measurements between 100° C. and 1200° C. (or about 212° Fahr to 2200° Fahr.).

The extreme delicacy of the telephone, combined with the direct-reading scale graduated either in Centigrade or Fahrenheit degrees, gives the instrument qualities which commend themselves at once to practical men. Being perfectly portable, with no adjustment to be made when placed in position, there is nothing to get out of order.

By means of a switchboard, any number of pyrometers may be connected to the same reading box, situated at any distance from the source of heat.

The instrument consists of two essential parts: the heating element and the indicator.

The heating element is a coil of fine platinum wire wound on a mica frame, the resistance varying with its temperature. This coil is connected to the pair of binding posts by heavier platinum wires, which are protected by a porcelain or silica tube. The latter also contains a second pair of heavy platinum wires coming from a second pair of binding posts and forming a loop which terminates at the junction of the other pair with the coil. These four wires are insulated or held apart from each other by passing them through holes punched in a series of mica disks, the whole fitting loosely into the protecting tube.

The second pair of leads, forming the loop, are provided as a means for the compensation of the platinum wire leads, and eliminate any effect due to proximity of exterior temperature or electrical influence in the wires connecting the heating element and the indicator.

The addition of these compensating leads also renders the indication of the heating element independent of the distance between the indicator and the source of heat.

The indicator has the form of a box with a scale calibrated in degrees Centigrade or Fahrenheit and a stylus or pointer, which can be moved along the scale wire. This box also contains two batteries and a switch and switch plug.

The operation is very simple. The heating element (the bulb containing the resistance wire) is placed at the point the temperature of which is to be measured. Connection is made to the four binding posts on the box. The switch plug is inserted on one or the other of the end holes of the switch, in order to connect one or the other of the batteries to the circuit. The pyrometer is now ready for making a measurement.

The stylus or pointer is slid along the scale wire, the telephone receiver being held to the ear, and the temperature is read off on the chart immediately below the point of the stylus on the scale when the ticking or humming noise in the receiver ceases.

A galvanometer may be substituted for the telephone receiver. In this case the pointer is slid along the scale wire until the galvanometer shows no deflection in either direction.

This new pyrometer is one of the features of the new catalog of calorimeters and pyrometers just issued by Messrs Eimer & Amend, of New York, which contains a great amount of useful and valuable information.

Haanel Tablet.

A plate cast in iron, size 24 in. x 16½ in., and only ⅛ in. in thickness, has been received at the Mines Branch of the Department of Mines, Ottawa, Ontario, Canada.

This plate has been sent to Canada from Sweden, and bears in clear block letters, varying in height from 1 in. down to as small as ⅝ in., the following inscription:

"This plate was cast in honor of the visit of Dr. Eugene Haanel by the Atkiebolaget Elektrometall from iron produced by the Electric High Furnace at Domnarfvet, Sweden, Jan 1, 1909."

It is quite difficult to cast such a plate, yet this one is clear and free from the slightest imperfection or defect. The edges of the letters are sharp.

This plate proves conclusively that it is possible to cast difficult castings using iron taken direct from the Swedish electric furnace (described in our last issue), without remelting the iron in a foundry cupola.

Notes.

Bureau of Standards Analyzed Samples.—The Bureau of Standards in Washington, D. C., announces that it is ready to distribute an acid-open hearth steel with 0.6 carbon, and that a new sample of Bessemer 0.4 carbon is also ready in place of that hitherto supplied but now exhausted. The next samples to be issued will probably be basic open-hearth 0.4 carbon (renewal) and a straight vanadium steel with about 0.2 per cent V.

Society of Detroit Chemists.—At the annual meeting of the Society of Detroit Chemists, held on May 28, the following officers were elected: President, Frank T. F. Stephenson, Chemical Department, Detroit College of Medicine; vice-president, L. D. Vorce, Pennsylvania Salt Manufacturing Company; secretary, H. C. Hamilton, Parke, Davis & Co.; treasurer, W. D. Wainwaring, Railway Steel Spring Company. The membership reported is 84. Regular monthly meetings were held through the year, with an attendance of about 50 per meeting.

Infringement Suit.—The International Acheson Graphite Company, of Niagara Falls, N. Y., has commenced an action in the United States Circuit Court for the Western District of New York against the Castner Electrolytic Alkali Company of the same city, alleging infringement of its patents relative to its methods of making graphitized electrodes.

The Free Public Library, of Newark, N. J., informs us that the former reading room on the second floor of the library building has been converted into the "Technical and Scientific Department." The room is open on week days from 9 a. m. to 10 p. m., and on Sundays from 2 to 9 p. m. The department contains about 6,000 books and 300 periodicals on technical and scientific subjects, including chemistry, physics, electrical engineering, electroplating, etc. The United States, English and Canadian patent office reports, including United States patent specifications may be consulted. The books are not for reference only; most of them may be borrowed for home use.

Graphite Greases.—The new folder, 273 I, issued by the International Acheson Graphite Company, describes their graphited grease products which are designed for gears, cup and ball-bearing use. In the manufacture of their graphited grease, this company uses the world's purest and best graphite, which is a perfect lubricant in itself. The graphite and grease are beautifully blended, and it is claimed that the resultant product will do far more work than any other grease product on the market, great value being given the combination by the superior lubricating qualities of the graphite.

Bacteriological Apparatus.—In their new catalog of bacteriological apparatus, the Bausch & Lomb Optical Company, of Rochester, N. Y., have added another interesting publication to their long list. Aside from being very complete, the catalog is of interest since it describes a new electric incubator, made in various sizes, which presents a number of unique features. These incubators are run on the main current without any auxiliaries whatever, and, being self-contained, they require no more space than does the ordinary laboratory incubator. The many advantages attending the use of electrically heated incubators are too apparent to call for consideration here. Several forms of opsonic incubators, of hot-air sterilizers, steam-pressure sterilizers, and autoclave, afford a wide range of choice, while the water baths and paraffin ovens listed answer all laboratory requirements. In addition to these items, such accessories as thermo-regulators, thermometers and burners are given careful attention.

The Book Departments of the McGraw Publishing Company and the Hill Publishing Company have consolidated under the corporate name of the McGraw-Hill Book Company, with offices after July 1 at 239 W. 39th Street, New York. This consolidation brings together two of the most active publishers of technical books in the country. The new company takes over the book departments of both houses with a list of about 250 titles, both industrial and college text books, covering all lines of engineering. It will continue as well the retail, importing and jobbing business of the two houses. The officers of the new company are: President, John A. Hill; vice-president, James H. McGraw; treasurer, Edward Caldwell; secretary, Martin M. Foss. Mr. Hill is head of the Hill Publishing Company, which controls the *American Machinist, The Engineering and Mining Journal,* and *Power and the Engineer.* Mr. McGraw is head of the McGraw Publishing Company, which issues the *Electrical World,* the *Electric Railway Journal,* and *The Engineering Record.* Mr. Caldwell has been manager of the McGraw Book Department for several years, and Mr. Foss manager of the Hill Book Department.

Nitric Acid from Air.—In the fixation of atmospheric nitrogen by means of electric discharges, a comparatively dilute mixture of nitrogen oxide gases in air is produced and one of the troublesome problems is the cheap transformation of this dilute gas mixture into nitrates or nitric acid. A recent British patent of Sir William Ramsay (26,981, 1907; May 20, 1909) relates to this problem. It is summed up in the Lond. *Elec. Eng'ing* of May 27, as follows: "In the electrical manufacture of nitrates from atmospheric nitrogen the oxides of nitrogen present in the air that has been blown through the arc forms a trate and finally separate these oxides, the mixture is passed under pressure into a system of pipes surrounded by liquid air.

The mixture condenses and is caused to flow down a fractionating column and meet the products of evaporation of the liquid air. Rectification takes place, and nitrogen escapes from the top of the column. The oxygen and the oxides of nitrogen are returned to the tank containing the liquid, but the oxygen is continually evaporating. When the oxides of nitrogen are sufficiently concentrated in the tank, the liquid is run off and evaporated, the gases being passed through a solution to form nitric acid or a nitrate. The oxygen is passed with fresh air to the electric furnace, and increases the percentage of oxides produced. In a modified arrangement the different gaseous constituents are separated by fractional liquefaction."

Electric Furnace Iron Ore Reduction in Sweden.—With respect to electric furnace plants for iron ore reduction, which was described and illustrated in the paper by Dr. Haanel in our last issue, we have received, through the courtesy of Mr. Louis Simpson, the following additional information: "The reduction furnace erected by the Aktiebolaget Elektrometall, at Donnarfort, Sweden, still continues to give every satisfaction. There are no indications of a possibility of excessive repairs. The output exceeds 3000 kg of pig iron per hp-year, and the consumption of carbon is less than 300 kg per 1000 kg of pig. Director Yugstrom, of the Iron works, read a paper lately at a meeting of the 'Jerukontoret,' at Stockholm, in which will be expressed his satisfaction with the results. The success of this high reduction furnace is, therefore, indisputable. The new two-phase steel furnace lately erected at Hagfors has been started. This furnace, for the refining of metal and the making of steel, is also reported to be a success. A new company to reduce iron ore is now being started, called the 'A. B. Trillhattans Elektriska Smaltverk.' This company will reduce iron ore and produce pig iron for iron foundries. The plant will consist of three reduction furnaces of 2500 hp each, making up-to-date arrangements for a final total construction of nine furnaces of 2500 hp each and one furnace of 1000 hp, or a total of 21,000 hp. As the first furnace of this type was only started late last year it can be claimed that no other electrical furnace has such a record." (See also a letter in our Correspondence columns in this issue.)

NEW BOOKS.

OSTWALD, WILHELM. The fundamental principles of chemistry. An introduction to all text-books of chemistry. Authorized translation by Harry W. Morse. 361 pages. Cloth, $2.25. New York: Longmans, Green & Co.

BILTZ, HEINRICH AND WILHELM. Laboratory methods of inorganic chemistry. 273 pages, illustrated. Cloth, $3. New York: John Wiley & Sons.

LEWKOWITSCH, J. Chemical technology and analysis of oils, fats and waxes. Fourth edition. Three volumes, 562, 824 and 414 pages respectively. $15 net. New York: Macmillan Co.

WANG, CHUNG YU. Antimony. Its history, chemistry, preparation, analysis, production and valuation. With complete bibliographies for students, manufacturers and users of antimony. With numerous illustrations. 227 pages. Cloth, $4 net. Philadelphia: Lippincott.

TOWER, WALTER SHELDON. The story of oil. 282 pages, illustrated. Cloth, $1 net. New York: Appleton.

KEANE, C. ALEXANDER. Modern organic chemistry. With 29 figures in the text, 517 pages. Cloth, $1.50 net. New York: Scribner.

BECK, R. The nature of ore deposits. Translated and revised by Walter Harvey Weed. Illustrated. Cloth, $6. New York: Hill Publishing Co.

MAYER, LUCIUS W. Mining methods in Europe. Written after a visit to many of the metal and coal mines in Great Britain, France and Germany; illustrated with drawings and photographs for the most part by the author. 178 pages. Cloth, $2.50. New York: Hill Publishing Co.

IDDINGS, JOS. PAXSON. Igneous rocks. Their chemical and mineral composition, with a discussion of the chemical and physical principles applicable to their study; and a statement of the qualitative and the quantitative systems of classifications in present use. 475 pages, illustrated. Cloth, $5. New York: John Wiley & Sons.

STEWART, R. WALLACE. An elementary text-book of physics. With 48 illustrations, 141 pages. Cloth, $1.50 net. Philadelphia: Lippincott.

COSGROVE, J. JOS. Sewage purification and disposal. 230 pages, illustrated. Cloth, $3. Pittsburgh, Pa.: Standard Sanitary Manufacturing Co.

MOORE, E. CROZIER SIBBALD. Sanitary engineering. A practical treatise on the collection, removal, and final disposal of sewage and house refuse, and the design and construction of works of drainage and sewerage, with numerous hydraulic tables, formulas and memoranda, including an extensive series of tables of velocity and discharge of pipes and sewers. Third edition, revised and in part rewritten by E. J. Silcock. In two volumes. Vol. 1: Sewerage, hydraulics, sewer and drain ventilation, sanitary fittings and apparatus. Vol. 2: Land drainage, sanitary notes, sewage disposal, refuse destructors, trade effluents, and sewage fungus. 566 and 428 pages respectively. Illustrated. Cloth, $14 net. Philadelphia: Lippincott.

BOOK REVIEWS.

REPORT ON THE MINING AND METALLURGICAL INDUSTRIES OF CANADA, 1907-8. Ottawa, Ont., Can.: Government Printing Office. 972 pages, with many illustrations, maps, etc.

Dr. Eugene Haanel's activity as the Director of Mines at Ottawa, Ontario, needs no comment in this journal. His commission reports on electric smelting of iron ore and steel making have made the Canadian Department of Mines famous all over the world, and some other reports, prepared under his direction, notably on zinc and peat, are also classics in their respective fields.

The present Report on the Mining and Metallurgical Industries of Canada is the latest product of this intensely practical activity of the Canadian Mines Department. "The report as a whole is comprehensive, and will meet the great demand made on the Mines Branch during the last year or two for special information on the subject. While the eminently practical character of the data furnished will enable the capitalist, manufacturer, and general reader to make deductions which should be invaluable when looking for profitable investment."

The report is very well written and profusely illustrated, with many maps, illustrations, etc. The report consists of two parts. The first (616 pages) relates to the general mining and metallurgical industries in Yukon Territory, British Columbia, Alberta, Ontario, Quebec, New Brunswick, Nova Scotia. The second part (300 pages) relates to structural materials (brick and tile, lime, sandstone, cement, etc.) in the various provinces. Mr. S. Groves is named as editor, and Messrs. D. D. Cairnes, R. R. Hedley, Fritz Cirkel, J. J. Bell, J. W. Bell and W. F. Jennison as special investigators in the different provinces.

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VECTORS AND VECTOR DIAGRAMS, APPLIED TO THE ALTERNATING-CURRENT CIRCUIT. By William Cramp and Charles F. Smith. 252 pages, illustrated. Price, $2.50 net. London and New York: Longmans, Green & Co.

A valuable summary of the general principles of vector representation, vector algebra, multiplication of vectors, etc., with special reference to applications in alternating-current theory, examples being taken from the theory of transformers, of single-phase and polyphase motors, etc. It is a useful and practical book for engineers interested in the theory of alternating-current phenomena.